DISCOVERY

Monthly Notebook

Van't Hoff's Chemical Revolution
Franco-British Television
A Russian View of Darwin's Theory
Desiccated Harvests

Geology and Building Materials

FREDERICK A. HENSON, B.Sc., Ph.D., F.G.S.

Flowers of the Chalk

Germs Defeated

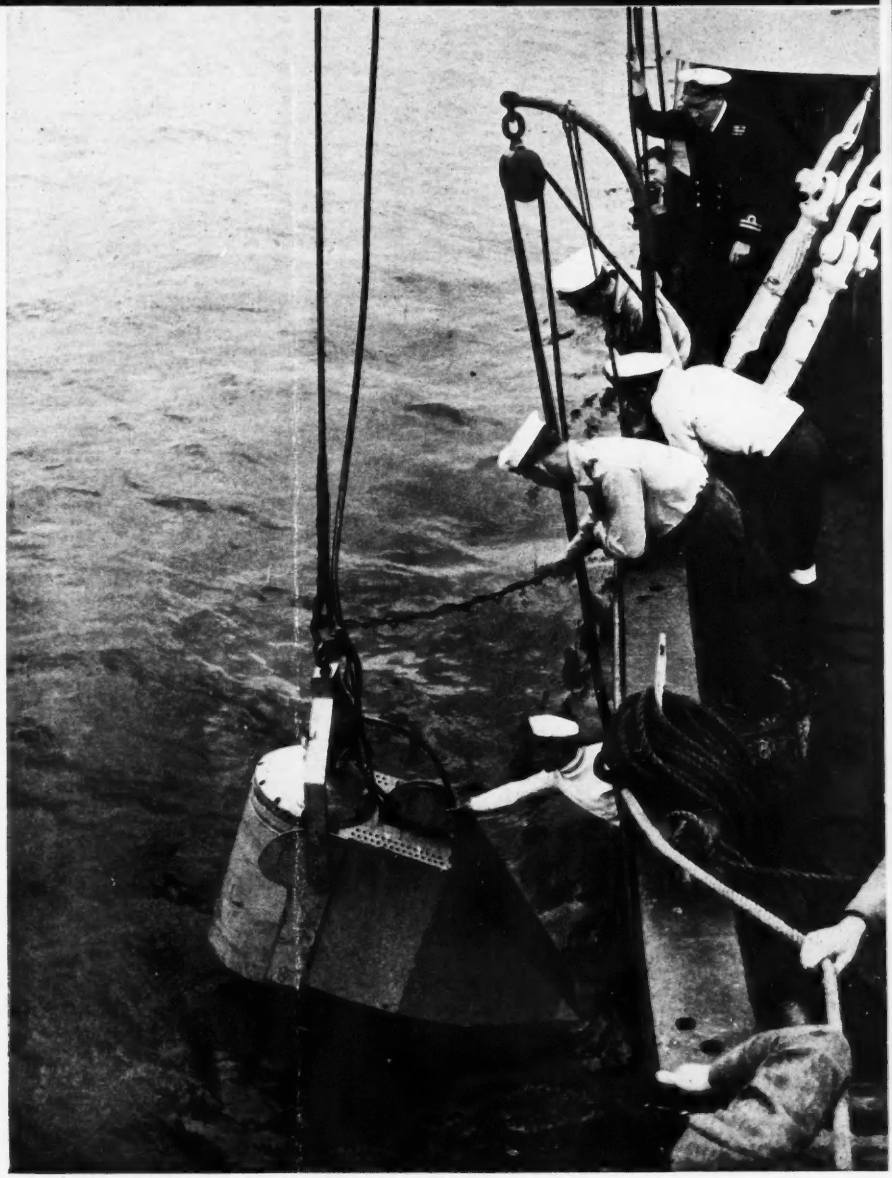
R. W. RICHARDS, B.Pharm., Ph.C.

Underwater Television

W. R. STAMP, B.Sc.

The Ethical Dilemma of Science

Prof. A. V. HILL'S Presidential Address to The British Association.



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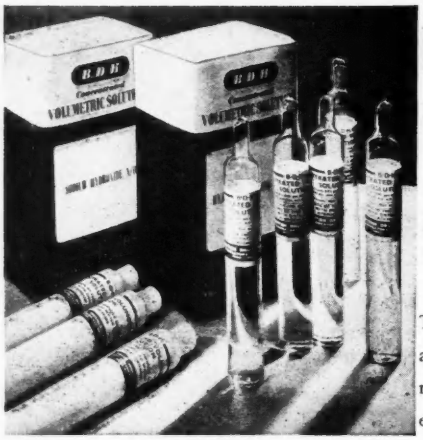

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From time to time various sections of the study of the structural features of cellulose and associated substances have been reviewed in text-books, but a great deal is still available only in the original papers. In particular no text-book has yet appeared in English confined to those aspects of wall studies of greatest appeal to botanists, and the growing demand for such an account has resulted in the publication of this book.

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The Progress of Science

Van't Hoff's Chemical Revolution

To every chemist the name of van't Hoff, the Dutchman who was born a hundred years ago—on August 30, 1852, to be exact—is known for his outstanding contributions to organic and physical chemistry. The son of a Rotterdam physician, he studied at Delft Polytechnic before proceeding to Bonn to work under Kekulé, whose structural formulae for carbon compounds constituted one of the foundation stones of organic chemistry. Kekulé's 'flat' formulae based on quadrivalent carbon atoms provided a useful diagrammatic representation of molecular structure, but they did not give anything like a complete molecular picture. It remained for van't Hoff to improve on Kekulé's ideas and develop space formulae giving a more accurate picture of the three-dimensional arrangement of the atoms of organic molecules; fundamental to this advance was the concept of the carbon atom as the centre of a regular tetrahedron with its four valency bonds radiating to the corners.

The existence of the isomers of such organic compounds as tartaric acid had puzzled chemists for a long time, and van't Hoff's solution of the problem and his clear thinking about the spatial arrangement of atoms within molecules, and about the type of formulae which could express the three-dimensional patterns of molecular structure, was followed by rapid progress. Pasteur had devoted a good deal of time to studying the tartaric acid isomers; he had established the existence of four forms of the acid, and in 1860 he posed this question: "Are the atoms of the dextro-acid grouped in spirals of a dextro-gyrate helix, or placed at the summit of an irregular tetrahedron?" Thus we see that Pasteur was near to solving the puzzle, but fourteen more years were to elapse before a thoroughly satisfactory explanation of the phenomenon of stereo-isomerism was to be published. This came in the form of a pamphlet written by van't Hoff. Two months later Le Bel advanced an essentially similar explanation in a French chemical journal. The two men had reached the same theoretical conclusions quite independently. Incidentally, their theory proved rather too revolutionary to win favour with many of the established chemists like Wurtz and Berthollet.

To lay the foundations of stereochemistry at the age of twenty-two was a brilliant achievement, but this was but the first step in van't Hoff's trail-blazing career.

In 1901 the first Nobel Prizes were awarded. The Physics Prize was awarded to Röntgen and the Prize for Physiology and Medicine went to von Behring. Van't Hoff won the first Chemistry Prize, and it needs to be recalled that the award had nothing to do with his work on stereochemistry, being given for the originality of his work in physical chemistry—specifically for his contributions to the understanding of the dynamics of chemical reactions and for establishing the laws of osmotic pressure. Van't Hoff had studied thermodynamics and applied its methods and results to chemical reactions. His conclusions were to revolutionise chemical thought. His 1884 monograph entitled *Études de dynamique chimique* must be ranked among the great classics of chemistry, and the extreme originality of the ideas it contained is made obvious by the one simple fact that contemporary chemists commonly called the book by another name—that name was *Révolution chimique*.

Van't Hoff's works were always so full of new and unexpected ideas that they shocked many experts into violent disagreement, though this reaction was totally eclipsed by the inspiration which the same ideas exerted on more receptive minds. The originality of van't Hoff's ideas has been well described by Svante Arrhenius (the Swede whose theory of the dissociation of electrolytes into ions won him the Nobel Chemistry Prize in 1903) in the following words, which were written in connexion with the proposal that the most appropriate person to receive the Nobel Prize in 1901 would be van't Hoff:

"Several circumstances led to the relatively early recognition of van't Hoff's discovery. At an early age (1874) he published a work on stereochemistry which brought down on his head the ridicule of conservative chemists, the ridicule which usually follows immediately after a great discovery. Since then his stereochemical work has received the recognition it so highly deserved. In 1876 appeared his brilliant book, *Ansichten über organische Chemie*, which, although it was loftily ignored by most chemists,

considerably increased his reputation with the rest. Finally, his splendid work, *Études de dynamique chimique* (1884), made him at once the most prominent man in physical chemistry. This treatise should be regarded as leading directly up to the great work for which it is proposed to offer him the prize. Quite apart from the fact that van't Hoff had thus already made a name for himself, which naturally made it easier for him to win recognition for his new work, the theory of electrolytic dissociation published simultaneously protected him from really violent attacks. Although the main controversy between the old and new ideas during the past fifteen years has concerned the problem of electrolytic dissociation, there have nevertheless been isolated and virulent attacks—for example that by Lothar Meyer—against van't Hoff's law. These attacks have been convincingly answered by van't Hoff himself."

Arrhenius's words undoubtedly carried great weight with the selection committee that had the task of deciding which of the world's great chemists should be awarded the Nobel Chemistry Prize for 1901. It represents a tribute from one great and original thinker to another. Arrhenius could speak with the experience of a man knowing intimately the kind of resistance which brilliant new ideas have to overcome, for no chemical theory ever had to meet fiercer criticism than did Arrhenius's own theory of ionic dissociation. In 1901 there was no need for the selection committee to hunt for names of chemists who were eligible for the Nobel Prize; there were many eligible candidates, and it was mainly a question of deciding in what order they should receive the award. It is a measure of the esteem in which he was held by his contemporaries that van't Hoff should have been named the first Nobel-prizewinner in Chemistry and that this award was universally approved.

Franco-British Television

ALTHOUGH marred by a few technical hitches at the outset, the television programmes received from France and broadcast throughout Britain during the week of July 8–14, were the result of an outstanding technical achievement which reflected credit on both the French and B.B.C. television staffs concerned in the transmissions.

The distance travelled by the signal was over 500 miles through nearly twenty relay stations making use of radio link and special cable, and in addition the two systems, French and British, were of different standards which had to be reconciled.

In April, preliminary tests between Paris and London had shown that the relaying of the television signal presented no insuperable difficulties, and with the previous experience of the programme relay from Calais it was decided to establish the experimental system of links to carry a special programme for a week.

The arrangements for transmitting the signal from Paris to the conversion station at Cassel were in the hands of the French engineers, but after this point the B.B.C. were responsible for relaying the converted signal to London. It is only fair to the British engineers to mention that the majority of the early breakdowns took place between Paris and Cassel.

The pictures received on the Outside Broadcast cameras were first radiated to the Eiffel Tower, whence they were transmitted to French viewers. A radio link designed by the engineers of Radiodiffusion et Television Françaises transmitted the signal to Lille and thence to Cassel at a frequency of 900 megacycles.

The French television system gives a picture composed of 819 lines, whereas that of the B.B.C. is based on 405 lines. The direct conversion of one system to another is not possible, owing to the differences in timing and synchronisation, and it was therefore necessary to record the picture and retake it on the British standard. This was done by displaying the original picture on a cathode-ray tube having a slight afterglow on the screen which showed an effectively continuous picture to the camera focused on it. The use of a long-persistence screen had the added advantage that it was possible to use a longer exposure on the recording camera, giving a greater signal output.

From Cassel to Alembon, a short distance, the radio link was provided by the B.B.C., and from thence the signal followed the route already used for relays from Calais: Swingate—Wrotham—London.

The task of relaying signals from France will be simplified in the future if the plans for extending the Grid system across the Channel can be carried out, as the interlocking of the supply frequency between the stations would maintain synchronism between the systems. It is, however, very unfortunate that there is no international uniformity in line standards, and the existence of no less than four different systems on the Continent will handicap the setting up of a permanent link with Europe.

The possibility of an Anglo-American television relay being developed in time for the Coronation to be seen

directly on U.S. television screens is being widely discussed, particularly in the lay Press. But in spite of the superior resources of America, the cost of such an undertaking would be prodigious, and the project seems to be so tentative that it must be relegated to the pipe-dream category so far as the year 1953 is concerned.

A Russian View of Darwin's Theory

A NUMBER of readers have written asking for more details about the celebrations recently held in Moscow to mark the occasion of the 70th anniversary of Darwin's death. In view of this interest we reprint below the following short article entitled "Development of Darwin's Theory in the Soviet Union" which was circulated by the Russian Embassy in London in connexion with those celebrations. It is written by Prof. Fyodor Dvoryankin of Moscow State University, whose views on so-called Darwinism are significant, and therefore are worth recording, because they typify the official attitude towards evolutionary questions which prevail in the U.S.S.R. at the present time. The full text of Prof. Dvoryankin's article reads as follows:

* * * * *

No other theory in the history of natural science has ever attracted such general attention for so long a period and called forth such contradictory opinions as the theory of natural selection put forward by the British scientist Charles Darwin.

When Darwin's principal work, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life* appeared in print in 1859, contradictory opinions were voiced as to the significance of this work. The views were divided in accordance with the two main trends in natural science.

The adherents of the doctrine of the immutability of species received Darwin's theory with unanimous hostility because to them it was the embodiment of anti-clericalism and materialism. On the other hand, the scientists who held materialist views greeted Darwin's theory as a new achievement of science that would enable man to make use of living nature for his own benefit and which could serve as a scientific basis for the historical method in natural science.

In general, progressive Russian materialist philosophers characterised Darwin's theory as a turning-point in the development of natural science, as the beginning of a new science.

D. Pisarev, the well-known Russian literary critic, philosopher, and propagator of progressive ideas in natural science, arrived at the following conclusion regarding the general significance of the theory of natural selection:

"In almost all branches of natural science Darwin's ideas are bringing about an absolute revolution. His discoveries will provide botany, zoology, anthropology, palaeontology, comparative anatomy, physiology, and even experimental psychology with a general guiding line that will help to connect the numerous disclosed facts and direct the minds of research workers to new and fruitful discoveries."

Russian biologists of the materialist trend criticised Darwin for employing the false doctrine of Malthus in his theory, yet, nevertheless, they were able to distinguish the main rational principles of Darwin's theory from this error.

It is said that Darwinism found its second home in Russia. It would be more correct to say, not as a boast, but on the basis of an objective scientific analysis of the entire development of biological science, that Darwinism found not its second but its real home in our country.

The creative development of Darwinism in the work of Russian scientists served to eliminate its shortcomings and errors and raised this theory to a higher level. Natural science, which primarily *explained* the past history of the organic world, is now becoming an effective means of *transforming* nature. The scientific achievement of creating this new dialectical materialist trend in natural science belongs to I. Michurin in the field of heredity, to I. Pavlov in the field of physiology and the elaboration of the physiological basis of the higher nervous activity, and to V. Williams who worked out the theory of phasic soil formation and created the scientific system used in socialist agriculture.

This scientific trend which, thanks to the daily solicitude of the Soviet Government and the Communist Party for science, has flourished and taken definite shape in Soviet times, is now headed by Academician T. Lysenko, O. Lepeshinskaya, and the pupils and followers of I. Pavlov.

First and foremost, the work of these scientists proves that Soviet biologists are successfully developing the scientific trend of I. Michurin and I. Pavlov. But these ideas have their roots in the materialist essence of Darwin's theory, and, therefore, they serve at the same time to develop this side of his teachings.

This is why the Michurin-Pavlov trend in science to which Soviet biologists adhere, is called Soviet creative Darwinism.

* * * * *

Relevant to the controversy over current Russian ideas on evolution and genetics are the comments made by Dr. S. M. Manton, F.R.S., reader in zoology at King's College, London, in the book entitled *The Soviet Union Today* in which she records the impressions of her brief stay in the U.S.S.R. last year. Her treatment of scientific matters is generally rather superficial, and her examination of the evidence on which the Russians base their claims about graft hybrids and genetic changes reputedly induced by vernalisation is not conclusive; only if the Russian claims are confirmed by repetition of their experiments outside the Soviet Union are they likely to gain any credence, and so far repeat experiments carried out abroad have not supplied any such confirmation. Dr. Manton's report on these biological matters is evidently a compilation of summarised quotations from Russian sources, and as genetics is not Dr. Manton's speciality she has wisely not attempted any critical examination of the material placed at her disposal. Convincing proof of the Russian claims could only be possible abroad if biologists who visit the U.S.S.R. could bring back some of the genetical material with which Russian scientists are working, but apparently Dr. Manton had no opportunity to do this. With regard to recent claims for 'spontaneous generation'—Prof. Lepeshinskaya claimed in 1950 that she had observed the spontaneous generation of cells in non-cellular organic material such as

egg albumen (see DISCOVERY, August 1950, p. 271)—Dr. Manton states "the matter now appears to be generally accepted as proven" in the U.S.S.R., but in her opinion "other possible interpretations of some of the observations occur to me", and she adds that the pre-war researches of Prof. P. D. F. Murray gave results incompatible with those claimed by Prof. Lepeshinskaya. "Not proven" is still the verdict in respect of all these controversial claims of the Russian biologists, and Dr. Manton's book, though interesting for its non-scientific chapters, does practically nothing towards dispelling the misty atmosphere in which these disputes will remain hidden so long as the Russians do not release the full facts and also some of the actual biological material used in their experiments for foreign scientists to study.

Desiccated Harvests

AN experiment which may provide an answer to the Government Working Party's report* on grain drying was carried out near Salisbury recently. Twenty-five acres of wheat and barley were sprayed from the air with a chemical solution which it was hoped would cause the grain to lose its high moisture content before combine harvesting, thus eliminating the expensive drying processes which combined grain often has to undergo. The spraying was done by an aircraft flying at 10 ft. Two different chemicals were used in this trial.

The results of this particular experiment, which were not available in time for publication in this issue of DISCOVERY, are awaited with considerable interest, for very promising results have been obtained in earlier trials carried out in America with chemicals which remove unwanted moisture from crops. A review of this work was recently given to the Guild of Agricultural Journalists by a British scientist, Dr. E. Holmes, who has witnessed some of the U.S. field trials.

For several years past a proportion of the cotton growers in the U.S.A. have applied to their crops, shortly before picking time, certain chemicals similar to weedkillers to cause premature defoliation. The main object of this has been to assist the mechanical cotton pickers and the strippers to work more easily and to leave fewer leaves in the picked lint for subsequent removal in the ginnery, i.e. the fibre-cleaning plant. A subsidiary object is based on the fact that after defoliation the humidity in the microclimate within the crop is lower and less damage is caused to the quality of the cotton fibre by fungus and bacterial organisms which can, and often do, cause staining and rotting. The chemicals used include chlorate mixtures and sodium cyanamide in spray solution, and calcium cyanamide dust.

* This report, entitled *Grain Drying and Storage in Great Britain*, is published by H.M. Stationery Office, price 1*s.* 6*d.*

In the United States a similar procedure has been applied, admittedly experimentally and still rather tentatively, to a number of other crops to cause desiccation for a rather different purpose. The desiccation work most nearly approaching commercial practice was the application of several different chemicals to rice in west Texas some seven to ten days before the normal time of combining. The chemicals applied stop normal physiological processes; in particular, they prevent translocation of moisture from the roots to the leaves and more especially to the grain in the head. As a result the moisture content of the grain falls appreciably more rapidly following treatment than it does under natural conditions. In a typical experiment, rice grain, which at the time of the application had a moisture content of 23–25%, showed a drop in moisture content by an average of about 2% a day, in an extreme case to as low as 8%. As this occurs in a region where rice has normally to be harvested when the moisture content is appreciably above the level of 14–16%, which is the highest that will allow safe storage, in other words where artificial drying is necessary, the implications of the process are obviously important. In addition, the cost of the chemical plus the cost of application was only about one-half the cost of artificial drying.

One unexpected result was pointed out, namely that the method gives a greater yield of crop. This seemed incredible until it was explained that the process resulted in a more even ripening; at the time of combining less grain was still green and therefore failed to be winnowed out of the husks, and, on the other hand, less grain was over-ripe and therefore shed before and during the process of harvesting.

It is quite obvious that it would be impracticable to drive land-spraying or -dusting machines through such crops as cereals just before harvest, and, as a result, all the applications seen were being carried out by aeroplane. Quite naturally, the American contract operators of aircraft are particularly interested in the development; so much so that, frankly, work is going along very empirical lines well ahead of adequate research by the Federal and State authorities, or even by the interested commercial firms. Not only is rice the subject of experimentation, but millets and even grasses, clovers and lucerne grown for seed are being treated.

It is too early yet to forecast how far this desiccation procedure will become incorporated into farm practice even in the United States, but Dr. Holmes said that it is obviously of such potential importance that experimental work will be pushed ahead there and should be pushed ahead elsewhere.

Exactly the problem outlined in the U.S.A. arises in Britain. Much combined grain, particularly barley, has to be dried artificially before it can be safely stored. The British experiment mentioned in the opening paragraph of this note was designed with this point particularly in mind.

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Geology and Building Materials

FREDERICK A. HENSON, B.Sc., Ph.D., F.G.S.

FROM the time primitive man forsook his austere cave-dwelling some fifty thousand years ago, at the end of the succession of Ice Ages, his successors have fashioned their dwellings in many different ways. The building materials used, both in the past as well as in the present, have been predominantly of local origin, and their character has been determined by the rocks occurring in the neighbourhood. Of course, there have been exceptions to this general rule; building and decorative stones, for example, have been imported for special purposes, while in some cases 'foreign' stones which merely happened to be available, having been brought in as ballast in ships, have found their way into buildings. But generally it is true to say that the mainstay of building is the local rocks, though the manner in which these are used depends upon the climate and also upon the level of technical skill existing in the community.

The first building materials were those materials which were ready to hand and which required little or no preparation before use. It is therefore logical to start with some of the older building methods, which depend on site materials requiring little preliminary treatment, before proceeding to review the great variety of rocks which have been exploited for building purposes.

It is not surprising that many of the most successful methods of building which have been used for thousands of years in the past still survive in many parts of the world. These methods are some of the cheapest, and yet some of the most satisfactory known. From ancient times, prepared earth and mud have been extensively used in the Middle East to create the main fabric of both small and large buildings. Many local soils, clays and other rocks from the immediate vicinity of building sites can be converted into building materials by a process similar to puddling. There are no transportation costs and no fuel is required to dry the materials, which are either daubed upon rough wooden frameworks or shaped into thick walls. These dry out comparatively quickly under the semi-arid conditions where this type of building is common.

Pisé de terre

In France, Italy, Spain, and even in this country, simple methods have been used since pre-Roman times. Pisé de terre, or rammed earth, is common in the Rhône valley in France; according to Pliny, the Romans used this medium to build watch-towers in Spain. Earth, containing up to 25–30% clay and 70–75% sand, is first prepared by mixing, raking and pounding. It is then rammed—special hammers are used for this operation—between wooden shuttering to form the main walls. Such walls, which are thick compared with conventional brick walls, are capable of lasting many centuries if properly looked after. Special care has to be taken while preparing the raw material, for the presence of too much clay (which when wet may contain up to 30 or even 40% water) will result in excessive shrinkage when it dries and the walls will crack badly. The ramming process demands both muscular and some mental effort to obtain the correct degree of compaction. By moving the shuttering around the main structure, and using two or two and a half feet 'lifts', the walls can be built with a minimum of equipment and with comparatively unskilled labour. On reaching first-floor level the joists can be laid across the main and secondary walls without delay, and the building of walls up to two or three storeys high can continue uninterrupted.

This method, though it is not suitable for general use in Britain, has the attraction of being cheap. Naturally, many refinements can be added, including brick or stone plinths for the walls and chimneys, and cement rendering of the main walls which makes for better preservation.

A similar method, and one which used to be extremely popular in Devonshire and the West Country, is known as *cob*. This traditional method, which has declined in popularity in urban areas within the last century owing to the widespread use of brick, has remained popular in rural districts. Here again the walls are comparatively thick and are generally built upon stone plinths; sometimes they are buttressed by local building stones. In this method, clay, soil and broken rock are mixed with straw and water, and the resulting mixture is then either spread in layers upon a reed or brush framework, or shuttered to form walls, which with due care and attention last for two or three hundred years.

Experimental houses built of chalk by methods similar to those just described, were recently erected at Andover in Hampshire.* Here, as with pisé, the walls were constructed between shuttering; they were supported on a brick base to lift them off the ground. In this case, the chalk from the building site was mixed with water and the mixture rammed between wooden shutters. In later experiments, the chalk was converted into building blocks; the method was to mix crushed chalk with water, the resultant 'pug' then being poured into moulds where it set hard without any ramming being necessary. After 24 hours the blocks were ready to be removed from the moulds, and these chalk 'bricks' proved satisfactory units for wall building when bonded with a moistened mixture of chalk and sand. These chalk houses proved cheaper than houses of the same size built of ordinary brick, but the technique is evidently one which requires careful control.

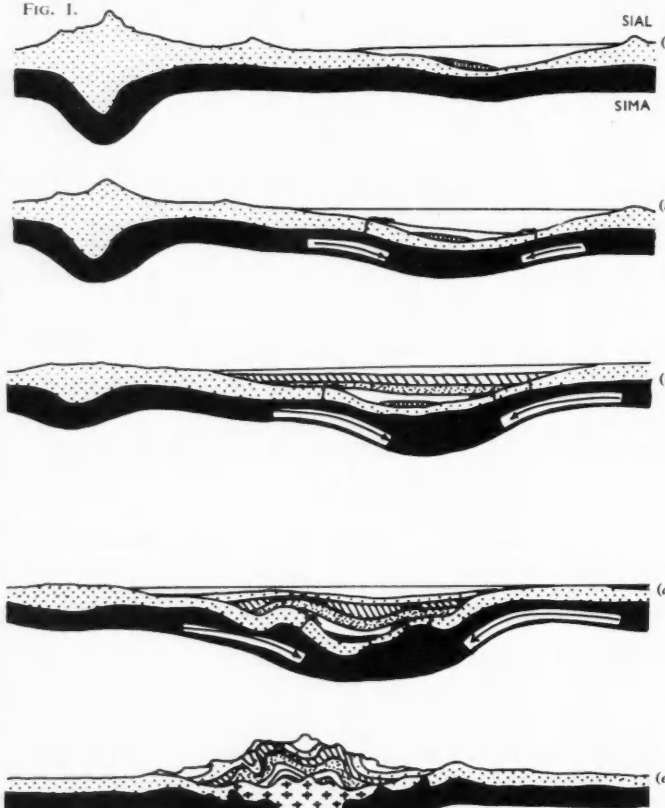
Adobe and Stabilised Earth

Adobe or unbaked bricks are very popular in Mexico. Sun-dried bricks of this type have been used for house building even in Britain; for instance, in East Anglia, certain clays have in the past been directly converted into bricks. Houses built from bricks which have been dried simply by exposure to sun and air are relatively cheap, but in Britain they need to be protected against rain and damp, which can be done by applying a waterproofing coat of cement wash or bitumastic preparation.

* An article describing this experimental building project was published in DISCOVERY, July 1949.

THE CONCEPT OF THE GEOSYNCLINE

FIG. 1.



These diagrams summarise the sequence of events which constitute the history of one geosyncline, and show how the rocks of the Sial and Sima undergo redistribution. (The lower boundary of the sima must only be regarded as conjectural, since the sima rests upon even denser rocks.)

(*a*) The beginning of the cycle with a mountain chain, complete with its 'root' in the sial, undergoing active weathering and erosion. The waste material is transported by streams and rivers to the sea, where it accumulates to form new sediments.

(*b*) As erosion of the old mountains continues, the new sediments accumulate in the geosyncline or trough. Weak currents in the sima, and the increased load of the new sediments, cause the geosyncline to deepen and the sea starts to creep over the old land surface.

(*c*) The mountains have been almost levelled, and the eroded material has been deposited in the geosyncline. The increasing load of sediment depresses the sima in the geosynclinal region, and this is accompanied by slow upward movement of the sima under the mountains—the effect is comparable to adding weight at one end of a seesaw to raise the other end. The mountain roots thereby become exposed to erosion.

(*d*) The geosyncline has now received its maximum load. The sial, under this load, loses its rigidity and starts to buckle; this foundering of the sial is assisted by stronger currents in the sima and the accumulated heat generated by the decay of radioactive minerals.

(*e*) The final stage, where the sediments have been folded into new mountains, complete with a new sialic 'root', due to the buoyant rise of the sediments caused by the melting of the sial and sima below the geosyncline. New granites (++++) occupy the core of the new mountains.

THE modern view is that our planet today has an outer shell composed of igneous rocks (i.e. rocks which were at one stage in their history molten) which is partially covered by a thin veneer of sediments. This outer shell is formed mainly of granitic rocks, which for convenience is known as the *sial*; below this outer layer comes the *sima*, composed of rocks which are slightly denser and mainly basaltic in character.* It is probable that this arrangement of sial upon sima originally existed in the early days of the earth's history, but there is some doubt whether the outer sial completely covered the sima.

Since those earliest days all rocks exposed on the earth's surface have undergone weathering and erosion. Over hundreds of millions of years this has resulted in a drastic redistribution of the materials which formed the original outer rocks. By careful observation of the present surface of the earth, and of the rocks themselves, the mechanism of this process has been elucidated. Rock fragments have been carried down to the sea which is virtually the dumping ground of rock waste from the land surface; at various times in the past extensive coastal regions have received vast quantities of rock waste, ranging from coarse beach deposits to colloidal particles. These trough-like areas which receive this waste are known as *geosynclines*.

In a geosyncline all the widely different sedimentary rocks such as clays, limestones, sandstones etc., can be deposited. During the later stages, when earth movements occur, the clays may be altered into slates and the limestones into marble by the tremendous pressures and heat involved. Granites and other igneous rocks form the core of the new mountains which are created at the end of the cycle.

In the Alps and Himalayas, rocks containing marine fossils are very common and clearly show that at one time these rocks were formed under the sea. They owe their present position and crumpled form to tremendous earth forces and movements which raised them from the sea-bed in the most recent mountain-building episode in the earth's history. By contrast the granite masses of S.-W. England, from Dartmoor to the Scilly Isles, are the roots of an ancient mountain range which came into existence after the formation of the Carboniferous rocks over 200 million years ago and have since been almost worn away.

* The mnemonic terms *sial* and *sima* are derived from *si*(lica) and *al*(umina) predominating in the outer shell, and *si*(lica) and *ma*(gnesia) of the heavier layer.

During the war years another way of using local site materials for the construction of airstrips, roads and even buildings came to the fore. In this method, known as 'soil stabilisation', cement is used in small quantities (from 4 to 10%) to bind the site material together quickly. In road construction, the cement is first distributed over the surface of the proposed road and then mechanically mixed with the soil; the ground is then watered and rolled. Within a few hours the 'stabilised-soil' road is capable of taking heavy traffic. In the construction of houses the earth-cement mixture is built up in walls between shuttering; in many of the recent experimental projects pneumatic hammers and steel shuttering (of the type used in reinforced concrete work) have replaced the traditional hand hammer and wooden shuttering.

So far in this article we have not considered the geological origins of our building materials. But when one comes to the building stones, such as granite and limestone, there is scientific interest in their origins and their chemical composition, which are not without practical relevance as the geological history of these materials and their chemical nature affect their performance as building materials. Here the reader will find the diagram on the opposite page useful; this is designed to summarise as concisely as possible the sequence of events whereby the igneous rocks which originally covered the earth's surface have been transformed to yield sedimentary and metamorphosed rocks* such as we see today. The mechanism of the *geosyncline* plays a most important part in the process, and its significance is brought out in the diagram.

Building Stones

First come the *granites* which are common rocks and widespread in their distribution. Unlike the sedimentary rocks they are not bedded. They occur in the form of massive domes which pushed aside the sedimentary rocks, and in the process sometimes altered them and partially absorbed them, since the granite masses were at one time capable of movement through the crystal rocks. In the British Isles, all the granite masses, with the two exceptions of parts of Charnwood Forest in Leicestershire and the Channel Islands, are found west of a line from Berwick to Start Point. In Scotland, granites form a great part of the Highlands; they are less common in the southern uplands. Granites also occur in Ireland (principally in the north where they are a continuation of the Scottish Highlands), in the Lake District, Anglesey, and in S.-W. England where they form the barren moors from Land's End to Dartmoor.

All these granites are wholly crystalline, and are relatively coarse-grained as the crystals of which they are composed are large in size, having been formed in the very slow cooling of huge masses of molten rock at considerable depths below the earth's surface. The formation of the granites in the 'infernal regions' leads to their being called *plutonic* rocks, which are quite different from the lavas resulting from the outpouring of molten rock on the surface of the earth.

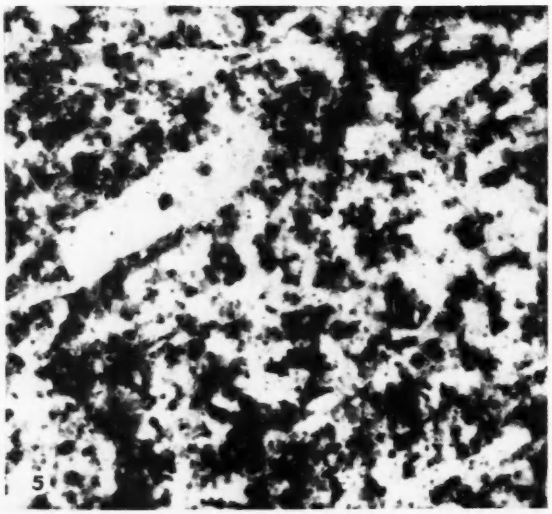
The granites of Britain are not all of the same age; they differ widely in their superficial character and also in their

* Geologists use the term *rock* in its widest sense to include not only massive rocks such as granites but also clays, shales, etc.

FIG. 2.—One of the experimental chalk houses built at Andover since the war.

FIG. 3.—Outbuilding on a Devonshire farm showing the use of cob and local stone. The stone is a coarse dolerite from an intrusive igneous sill two hundred yards from the building; the cob is composed of site materials.

FIG. 4.—Modern Cotswold houses; their style is new, but they are built of the traditional local oolitic freestones.



BUILDING STONES UNDER THE MICROSCOPE

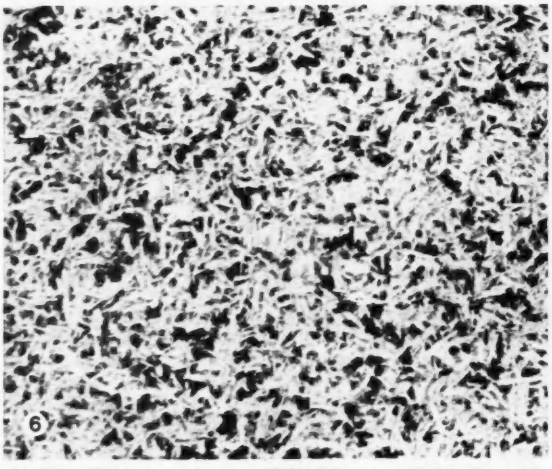
FIG. 5.—Dartmoor granite, natural size. The mottling is due to the variety of constituent minerals. The large white crystal is potash felspar; the smaller white crystals are potash and soda felspars. The darker mineral with numerous cracks is quartz. The small black specks are iron ore and mica.

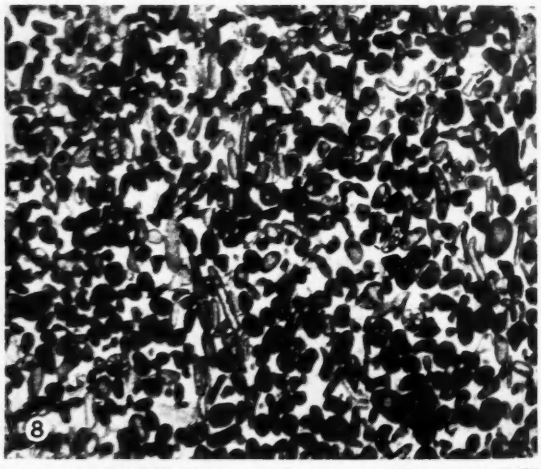
FIG. 6.—Basalt, ×12. A very fine-textured rock composed mainly of lime-rich felspars, augite and black magnetite. (Locality Arran.)

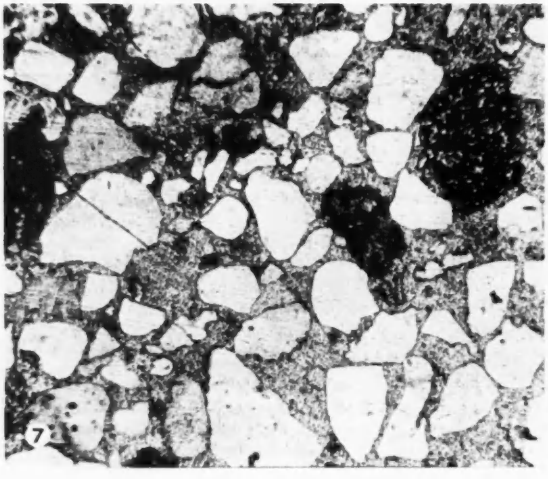
FIG. 7.—Sandstone, ×12. This sedimentary rock consists mainly of subangular quartz grains cemented together; the photomicrograph also shows a few dark fragments of an older rock. This open sandstone is porous and friable, and is not a good building stone. (Locality, Nottingham.)

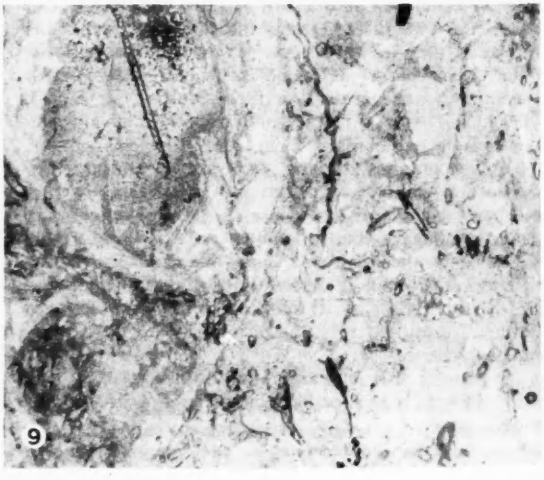
FIG. 8.—Oolitic Limestone, ×12. The rounded ooliths of this freestone are clearly visible; shell fragments are also seen. (Locality, Ancaster.)

FIG. 9.—Shelly Limestone, ×12. This rock is composed of innumerable shell fragments cemented together with calcite. It is mainly suitable for decorative work; it can also be used for walling.









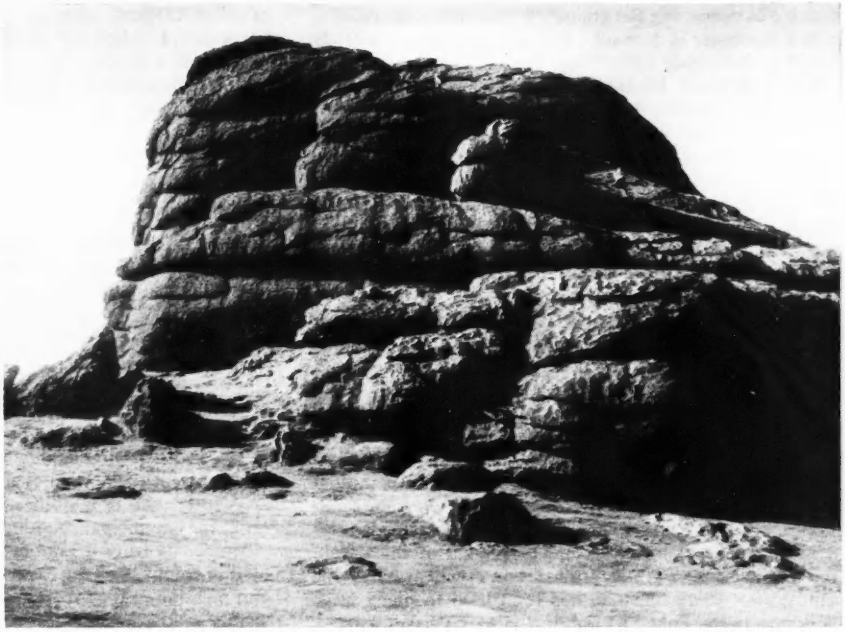


FIG. 10.—Hay Tor, formed of granite and rising to over 1400 feet, is a well-known geological feature of S. Devon. The rock illustrates the block jointing characteristic of granite; two sets of joints—one horizontal and the other vertical—are seen in this photograph.

mineralogical composition. But they have one thing in common—they are all rich in quartz.

The principal minerals present in granites are: *quartz* (SiO_2), *potash felspar* ($KAlSi_3O_8$) and *soda felspar* ($NaAlSi_3O_8$). Granites also contain other minerals, of which the micas are the most important.

At first sight a natural granite mass seems to be a very solid object, but one commonly finds that it is in fact divided up into blocks by a series of *joints*, to use the technical term. This feature can be seen on many granite tors and mountains. The natural jointing, which arose during the cooling of the rock, is exploited in the working of a granite quarry.

Granites in general give a tough and pleasing building stone. Most granites are light in colour, and medium- to coarse-grained in texture with the felspar crystals varying from dull white to deep red in colour (depending upon the amount and state of the iron present in the felspar) and embedded in a mosaic of quartz and other minerals. In some granites the felspar decomposes rather quickly and the iron oxidises causing an effect known as bleeding, which detracts from its value for decorative purposes. Some of the best-known granites come from the Aberdeen area, Shap Fell, Mountsorrel, St. Austell, Dartmoor and the Channel Islands.

One might expect that occasionally the kind of sialic magma which gave rise to granites would have been brought to the surface by volcanic action and would then have yielded rocks of a similar chemical composition to granite. In actual fact, few large tracts of such rocks occur; some of the best examples are to be seen in Jersey. These rocks, which are called *rhyolites*, are very hard and are not jointed, for which reason they are rarely used as building stones.

By contrast the extrusive rocks derived from the sima are very abundant, forming extensive areas in Northern Ireland and western Scotland for instance. These *basalts* are very different from granite. In colour they are dark green to black, and are composed of very small crystals characteristic of rapid cooling and crystallisation. These rocks are more basic in chemical composition than the granites, and contain only 45–50% SiO_2, as against the 66–75% SiO_2 present in granites. Their constituent minerals include basic felspars (quartz, potash and soda felspars do not occur), and also minerals rich in calcium, iron and magnesium and iron ores such as magnetite and haematite. Sometimes these basic lavas cooled so quickly that the resultant rock is glass-like. Their jointing is quite different to that of granite; the perfect columnar jointing of the basalts of the Giant's Causeway, Co. Antrim, provides a well-known illustration of this difference. The basalts are infrequently used for building, except for local buildings in basalt country, the main reasons being that they are not so easy to work as granite, and people generally prefer the mottled and light-coloured granite to sombre basalt.

Quartz, derived from granite rocks which have decomposed, forms the basis of the great bulk of sandstones and grits. During their transportation from the mountains to the sea the quartz crystals lose their sharp edges and become rounded. Their final size is of the order of 0·1–2 millimetres in diameter. The great bulk of the sandy beaches which fringe the coast of Britain is composed of such well-worn quartz grains. When a deposit of this material, as for

instance a sandy beach deposit, meets some substance capable of cementing the grains together, the rock which is called *sandstone* is formed. Typical cementing materials are lime, iron oxide and silica.

Many different kinds of sandstone occur in Britain. Some, for example, were originally sand-dunes which existed when this country was a desert; the sand-grains making up these sandstones were polished by collision with each other promoted by wind action, and typical of such sandstones are those which formed in the Triassic period. (The Triassic sandstones are mainly derived from accumulations of sand deposited by wind action. But many of these rocks also show 'current bedding'—that is, bedding due to the action of water currents.)

Quartz sand-grains make up the bulk of a sandstone, but other minerals are usually present. These other minerals include felspar (mainly the potash and soda varieties) and iron compounds; occasionally one also finds particles of the original granite from which the grains of quartz derived.

Sandstones in which the sand-grains are coarse and the cement is weak are unsuitable for building purposes, though they can be crushed to make building sands. In some sandstones, of which the Permian desert sandstones from Penrith is an excellent example, secondary growth of silica from the original quartz grains produces an excellent hard, fine sandstone. This sandstone has been used in many large buildings in the Lake District, including Carlisle Castle.

The finest particles of minerals resulting from the decomposition of rocks—ranging in size from 0·01 millimetre in diameter downwards to particles of colloidal dimensions—end up in the clays forming the bottom of the sea. These clays, when associated with the geosyncline (Fig. 1), may be converted into a mudstone, a shale or even a slate by high pressures developed during the mountain-building stage, which squeeze out the water. Slate is the only one of these three types of rock used in building. It is a traditional roofing material, and slates for this purpose have been quarried for several centuries in North Wales and Cornwall.

Limestones

Finally we come to the limestones. These are bedded rocks formed predominantly of calcium carbonate and are mainly of marine origin. In composition, texture and colour they vary greatly, and this also applies to the nature of their fossil content. The fine, compact limestones rarely contain recognisable fossil remains, whereas the coarse, shelly limestones consist largely of whole shells and shell fragments cemented together by the mineral calcite ($CaCO_3$). Some limestones are impregnated with limonite (an oxide of iron), which gives them the rich colour familiar to everyone who has seen the stone-built houses of Northamptonshire.

The oolitic limestones of the Jurassic period are familiar building materials. These limestones consist of grains which are spherical in form or egg-shaped; each grain is composed of calcium carbonate which was deposited around a nucleus. (The nuclei could be either organic, for example a shell fragment; or inorganic, e.g. a small sand-grain.)

Chalk is a very fine-textured pure limestone, composed of pure calcium carbonate, and containing abundant foraminifera. Chalk varies from a soft, almost incoherent material to a hard rock which can be quarried and used as a building stone. In colour, chalk is generally white, but occasionally grey due to small amounts of clay being present. The upper part of the chalk in South and East England is characterised by flint horizons.

Local Geology Reflected in British Buildings

In this country, which contains representative rocks of all the major geological periods and mountain-building episodes, the materials available for building are very varied. It is not proposed to catalogue the rocks commonly used for building; instead, a few areas characterised by the widespread use of local materials will be described. Readers will be able to see in their own districts how the materials used in the construction of historic buildings such as castles, churches, inns and older houses reflect local geology.

The Scottish Highlands are largely composed of older metamorphic rock, granites and volcanic rocks, all of which are widely used in buildings, from the humble croft to the imposing municipal building of many northern cities. Aberdeen is truly a granite city. The local granites are light in colour, they are easily worked and are both durable and pleasing to the eye. Dressed or polished granite withstands weathering, and in the past the granites of the Highlands have been widely used for decorative work. Granites are also used in the West Country, the Channel Islands, the Lake District and Leicestershire.

By contrast, the industrial lowlands of Scotland contain many sandstones, both Carboniferous and Triassic in age, which are popular for building. Unfortunately such rocks, although easily worked by masons, have a tendency to acquire a hard, sooty exterior in grimy industrial areas.

In northern England, the Carboniferous rocks, including limestones, sandstones and the Coal Measures, are the principal sources of building materials, although the overlying Triassic rocks are used in a few localities. The Carboniferous limestone varies considerably in its composition and texture, but generally gives a good stone of slightly greyer appearance than the yellow iron-stained limestones of the Cotswolds. The Millstone grits, like the Triassic sandstones

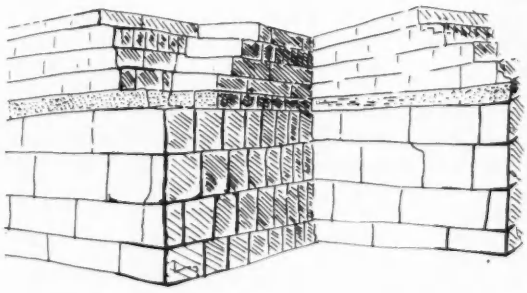


FIG. 11.—Diagrammatic sketch of a limestone quarry illustrating joint systems developed in the rock by tensional forces in the earth's crust. In this case the east–west joints are more numerous than the north–south series. Joints in limestone are often widened by solution.

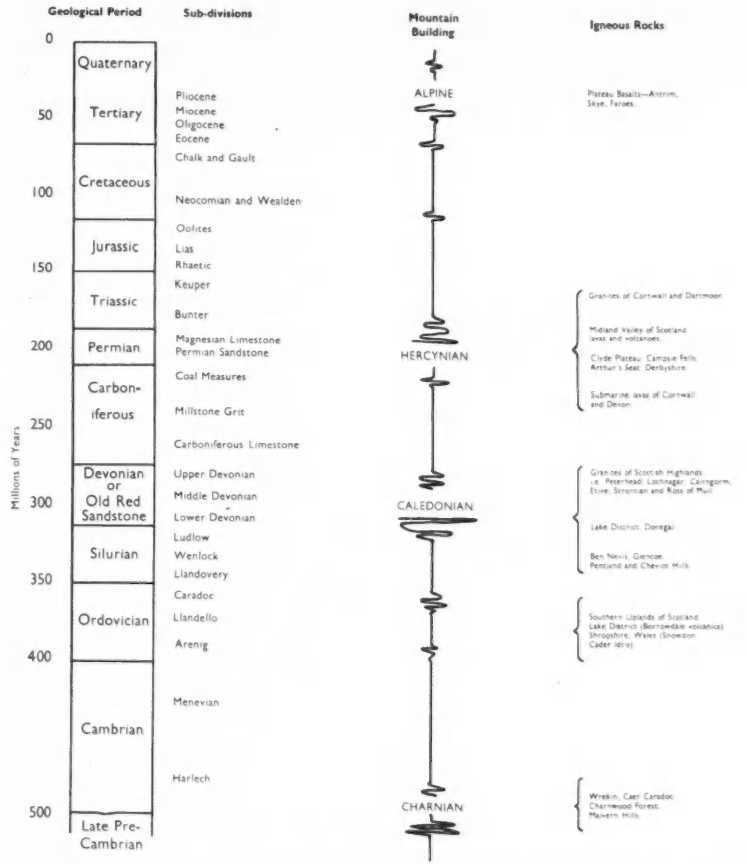


FIG. 12.—The ages of the various Geological Periods, indicating when the major mountain-building episodes occurred and when the igneous rocks associated with particular sedimentary strata were formed.

of central Scotland, become begrimed with soot in industrial areas, although many of the fine sediments of this formation are first-class freestones. The thinly bedded sandstones and grits give excellent flagstones which are widely used for paving and occasionally for roofing.

The Jurassic rocks form a continuous belt from the Cleveland Hills to near Portland and provide many of our finest building stones, as well as the raw materials for cement and iron. In Northamptonshire and Rutland many of the iron-rich limestones are used for building; the village of Rockingham has often been featured as a delightful example of the harmony of stone-built houses and the countryside. Farther south many of the old churches, farms and houses are also built of these mellow stones. The Upper Jurassic limestones are lighter in colour; they are, however, fine freestones and widely used both locally and in many other parts of the country.

The Cotswolds are a well-known area where local materials provide the building media, not only for walls and main structures but for roofing and decorative work as well. These Jurassic limestones vary in thickness, in grain and in colour so that local builders in the past have had a wide choice of materials on the spot. There are many beautiful Cotswold villages and to cite one would be an affront to the others. However, the city of Bath must be mentioned as an example of fine building and planning, unrivalled for the grace and beauty of the sweeping crescents and the warm charm and character of the magnificent buildings in the centre of the city. Bath is built of local oolitic freestones.

In the West Country, much use is made of local rocks in building. Local granites, basalts, limestones, sandstones and slates have all been extensively used to advantage. An hour's walk in Exeter reveals the local red sandstones, breccias, pale limestones and mottled granites in profusion in the older buildings; even the pavements are built of granite slabs in which giant felspar crystals (potash variety), up to three inches in length, are abundant. In rural areas, however, the widespread use of cob walls is characteristic of the lower areas, whilst on the moors granite comes into its own. Locally such rocks as gabbro, serpentine and slate are used in the walls of the older cottages.

In the areas briefly described above, local building materials predominate, but in most areas today brick-built far outnumber stone-built buildings. This is particularly true of industrial and urban areas where the demand for more and more homes has resulted in the widespread use of machine-made bricks for speed and economy in building.

The major part of Prof. A. V. Hill's presidential address to the British Association—which was delivered on September 3—was devoted to a discussion on ethical issues which the modern scientist has to face and resolve. We reprint here the whole of that portion of his speech. Our report of the rest of the British Association proceedings will appear next month.

The Ethical Dilemma of Science

Prof. A. V. HILL, C.H., O.B.E., F.R.S.

The Duke of Edinburgh concluded his presidential address last year with the words:

> "It is clearly our duty as citizens to see that science is used for the benefit of mankind. For, of what use is science if man does not survive?"

Here was a challenge to his successor: to discuss how far science has already contributed to human betterment, how far it has provided fresh problems, dangers and difficulties; and to suggest ways in which all who are concerned with science can help, as citizens, to make sure that its results in fact are beneficial.

As citizens: for scientists as such have no title to superior wisdom or virtue, and outside their special knowledge they are just as likely as others to be misled. The fundamental principle of scientific work is unbending integrity of thought, following the evidence of fact wherever it may lead, within the limits of experimental error and honest mistake. On this there can be no compromise. And since science is a universal interest of mankind, recognising no barriers of race, class, religion or opinion (provided that is honest), a necessary condition of its advance and application is one of friendliness, frankness and equality. Goodwill and integrity, therefore, are indispensable alike to scientific progress itself and its successful employment for the benefit of mankind. Those who look to scientists as magicians, able to conjure a universal formula out of a hat, may be disappointed to find only so ancient a doctrine: and admittedly there *is* far more to science than integrity and goodwill. But these are the qualities chiefly required to utilise the opportunities, to resolve the problems and difficulties, which science has provided for present-day society.

The common phrase, "this scientific age", is all too apt to imply, with little justification, that the majority of people, at least in highly developed countries, now think and act scientifically; and, with no justification at all, to suggest that science can replace the older motives of human conduct. It is true that the external circumstances of life have been vastly altered by the applications of scientific discovery and invention, though as yet for only a minority of mankind. The future alone can decide whether natural resources and human ingenuity will prove sufficient, given statesmanship and goodwill, for the same transformation gradually to affect the whole of human society. If not, are stable conditions ultimately possible? Or will there be perpetual conflict between the 'haves' and the 'have-nots'? It is true also that the methods, ideas and results of scientific inquiry have penetrated widely, if not deeply, into popular thinking and belief: the jargon at least of science is widespread, and magic and superstition are gradually losing, if not their currency, at least their respectability. Yet such changes may have little real influence on the basic pattern of human behaviour, and if witches are no longer hunted down and killed, political and racial intolerance can lead to even wilder and crueller excesses. In clearing away old idolatries there is always a danger of allowing new ones to creep in: the unclean spirit went out when the house was swept and garnished, but only to return with seven others more wicked than himself. The improvement of man's estate by the application of scientific knowledge is one of the loftiest of adventures: but a belief that it can be achieved by scientific methods alone, without a moral basis to society, is a perilous illusion. If the methods of human experiment and racial improvement adopted by the Nazis could be regarded purely as applied biology, there might be much to say for them. But most of us believe that by abandoning a faith (which has nothing directly to do with science) in the sanctity of the human individual and of moral law, they were heading straight for disaster. Yet we shall see later the dilemma in which such scruples put us, in respect of the gravest of all world problems.

The conflict between new knowledge and traditional belief is no novelty. When Eve saw that the tree of knowledge was good for food and that it was pleasant to the eyes, and to be desired to make one wise, she took of the fruit thereof and did eat and gave also to Adam and he did eat. Which led, as you have read, to their exclusion from the garden and the warning, "in sorrow shalt thou eat of it all the days of thy life". Again and again the attempt has been made to forbid the fruit of scientific knowledge. In 1874 in this city John Tyndall delivered a presidential address to the British Association which provoked a hurricane of controversy: the records tell us that it was denounced from every pulpit in Belfast. Yet, reading it now, one is impressed not only by its courage but by its reasonableness. It is true that he claimed that science will wrest from theology the entire domain of cosmological theory, whether of living or of non-living things; but he had previously referred to the immovable basis of the religious sentiment in human nature, bringing, as he said, "completeness and dignity to man". The views of Lucretius and Bruno, Darwin and Spencer, might be wrong: whether right or wrong, he insisted, we claim the right to discuss them. If today I claim the right to discuss not only the scientific facts themselves but their consequences in human affairs, I doubt whether denunciation will follow: if it does, I shall be sorry but unrepentant.

The development which has brought most vividly to the public conscience today the ethical problems aroused by the advance of scientific knowledge lies in the field of nuclear physics; and groups of scientific people in the free countries of the world are vigorously debating its various consequences, among them particularly the secrecy attached to weapons as new and devastating as those provided by nuclear fission. Atomic physics, however, is only one of many scientific developments which have brought, or are bringing, a mixture of possible good and evil about which judgments of relative value must be formed: we must not get too excited about one of them. There is no secrecy about most of these developments, they occur gradually and continuously before our eyes, we tend to accept them without question as though they were natural phenomena: yet in fact the consequences of one of them provide the most solemn problem in the world. The dilemma is this. All the impulses of decent humanity, all the dictates of religion, and all the traditions of medicine insist that suffering should be relieved, curable disease cured, preventable disease prevented. The obligation is regarded as unconditional: it is not permitted to argue that the suffering is due to folly, that the children are not wanted, that the patient's family would be happier if he died. All that may be so; but to accept it as a guide to action would lead to a degradation of standards of humanity by which civilisation would be permanently and indefinitely poorer. Conduct usually falls short of principles: but that would be the worst reason for abandoning principles altogether.

In many parts of the world advances in public health, improved sanitation, the avoidance of epidemics, the fighting of insect-borne disease, the lowering of infantile death rates and a prolongation of the span of life have led to a vast increase of population. Not only is the population increasing but in many places its rate of increase is still rising: and these processes will take so long to reverse that for many years to come the shortage of natural resources, particularly of food, is bound to provide increasing deprivation and disturbance. That provides the practical motive of the Colombo Plan. In India, a Government Planning Commission

in a report of July 1951 entitled "The First Five-Year Plan", has dared to face the facts. A doubling in the last thirty years of the survival rate (births minus deaths) has led to a rate of increase of nearly 1½ per cent per annum, a total of 5 millions every year in a population of 360 millions.

> "With all the effort that the First Five-Year Plan will represent, it will be possible barely to restore by 1955–6 the pre-war standards in regard to food and clothing. Increasing pressure of population on natural resources retards economic progress and limits seriously the rate of extension of social services so essential to civilized existence."

The pre-war standard, in fact, was miserably poor, a large part of the population existed below the level of a decent life, scores of millions only just above that of famine. Yet the gigantic national effort proposed in the Five-Year Plan, even if successful, may only just restore that miserable standard. Can it sustain it then if the rate of population increase continues? It is easy to answer that a higher standard of life has led in other countries to a gradually falling birth rate: but a higher standard requires a far greater charge on natural resources of all kinds, which cannot be met until the pressure of population is reduced.

In the meantime there is more than danger that the emergency will result in an over-use of natural resources, leading by land erosion, deforestation and other factors to permanent and irretrievable loss: this has happened already, and is visibly happening now, in many parts of the world. In a special section on "Family Planning" the Indian Report recognises that "an alteration in population trends takes at least a few generations to materialize"; and steps are suggested for the education of public opinion on the need for limitation, and for experimental efforts to be made in the application of simple methods of birth control. For its wisdom and courage in acknowledging the gravity of the situation the Indian Planning Commission deserves every support: but the problem itself has not begun to be solved, and its consequences will dominate the development of India for many years; indeed, its gravity will continue to increase. Malaria is admitted by the Planning Commission to take an annual toll of a million lives; tuberculosis of half a million. The resolute use of insecticides and anti-malarial drugs could soon reduce the former to a small fraction: tuberculosis is bound to require more effort and a longer term. Nobody would dare to say that steps to combat these diseases, and others such as cholera, to improve rural and industrial health, to increase the supply of drugs and medical equipment and services, should not be taken on the highest priority: but the consequence must be faced that a further increase of a million people per annum would result. Thus science, biological, medical, chemical and engineering, applied for motives of decent humanity entirely beyond reproach, with no objectionable secrecy, has led to a problem of the utmost public gravity which will require all the resources of science, humanity and statesmanship for its solution.

The example of India has been taken because of the sheer magnitude of the problem, and because its seriousness is now admitted by humane and responsible men: but the same conditions exist already in many parts of the world and will soon exist elsewhere. It is *not* a question only of food: if a higher standard of life is to become universal, with education, communications, housing, reasonable amenities and public health, a far greater demand will be made on all such natural resources as power, chemicals, minerals, metals, water and wood. One is left wondering how long these can possibly take the strain. Could world supplies conceivably hold out if the present requirement per head, in the United States, were multiplied in proportion to meet the same demand everywhere—even without any increase of present population; and if so, for how long? There is much discussion of human rights. At what level can these be reasonably pitched? And do they extend to unlimited reproduction, with a consequent obligation falling on those more careful? These problems must be faced not only with goodwill and humanity, but also with integrity and courage, not refusing to recognise the compulsion of simple arithmetic. It is right that the scientific imagination should be allowed to play sometimes with the more distant future, when possibly new methods and resources may be found to solve all problems; but only on condition that our minds are not deflected from the urgent realities of the present.

By vast improvements in communications, which have made the world so small, applied science has been one of the chief agents in the present ferment of social, political and economic thought. Can one urge, after the event, that the application was a mistake and that the majority of mankind could better have remained isolated and in ignorance? By making world war technically possible, applied science has helped to stir up national ambitions and social revolutions which, if poverty and deficiency continue without hope, may lead to major world catastrophe. Should we therefore refuse to employ science in defence of liberty and resign ourselves to a universal police state where no scruples are permitted? Are we, in scientific research, to say that some subjects may be investigated, but not others for fear of the consequences? Who then is to decide and by what international authority? And is it practical to insist that all scientific knowledge should be fully and openly disclosed, without secrecy or reservation of any kind, military or industrial? These are problems which cannot be solved by rhetoric, or by any simple formula. The purpose of setting them out is to make clear that we must face them with honesty and courage; for they will not solve themselves.

I have led you to the ethical dilemma which perplexes many of us by taking an example in which few would question either the motives of those who made the original discoveries, or the humanity of their application: or indeed could wish that the fruit of the tree of knowledge had been left untried. It is easy to say now that side by side with the control of disease there should have been an equal and parallel effort in education, particularly the education of women as responsible citizens: for there is no possibility, if women remain ignorant and illiterate, of intelligent widespread family planning and control. But education alone would not have been enough, or indeed possible itself without a substantial measure of material and social betterment: and the expense and effort involved in this would have been indefinitely greater than in the application of medicine and hygiene, which after all has been relatively cheap. Had it been possible to foresee the enormous success of this application, would humane people have agreed that it could better have been held back to keep in step with other parallel progress, so that development could be planned and orderly? Some might say yes, taking the purely biological view that if men will breed like rabbits they must be allowed to die like rabbits, until gradually improving education and the demand for a higher standard of life teach them better. Most people would still say no. But suppose it were certain now that the pressure of increasing population, uncontrolled by disease, would lead not only to widespread exhaustion of the soil and of other capital resources, but also to continuing and increasing international tension and disorder, making it hard for civilisation itself to survive: would the majority of humane and reasonable people then change their minds? If ethical principles deny our right to do evil in order that good may come, are we justified in doing good when the foreseeable consequence is evil?

I remember asking an eminent Indian who had taken part in drawing up the so-called Bombay Plan of 1944 why there was no mention of the gravest problem of all, overgrowing population: he replied that his colleagues and he had indeed discussed it, but decided to leave it to God. To a biologist aware of the methods by which animal population is in fact controlled by nature, this seemed pretty poor comfort: yet there are many who really take that view, admittedly with the element of reason that we never can be sure that things may not turn up to make all our calculations wrong. Should we then just continue to do the good we see in front of us, in confidence that if our motives are humane, good and not evil will finally result? Or, taking that rather easy course, are we not showing a lack of the fundamental virtues of courage and integrity?

The dilemma is a real one, and cannot be resolved by any simple expedient. In another form it is perplexing many of those who are concerned with the development of nuclear physics, the ultimate service of which may be very great, possibly essential, if our present type of civilisation is to continue when other sources of power dry up; while the benefits to medicine and industry are already substantial. *But*—nuclear fission has released the threat of unprecedented violence, with the possible destruction of many millions

of lives and the accumulated treasures, moral and material, of civilisation. The individual conscience may tell a man to have no part in it: that is easy enough, for there are plenty of other interesting things to do, but it does not solve the problem. Moreover, it is possible that defensive weapons, based on nuclear fission, but not of the type intended for mass destruction, can be developed, which would make armed aggression intolerably costly. What then of the abolition of secrecy? In principle, yes, for the historic and unique contribution of science to international goodwill has been in sharing knowledge regardless of race and frontier, and the chief satisfaction of scientific work, the condition of its fruitful development, is frank and free discussion. "Cast thy bread upon the waters, for thou shalt find it after many days", is wise and acceptable counsel in dealing with scientific knowledge: while "he that observeth the wind shall not sow and he that regardeth the clouds shall not reap", is as aptly applied to human relations as to agriculture. Every possible endeavour, therefore, should be made towards international agreement on sharing scientific and technical knowledge and controlling nuclear weapons: but this, like peace itself, is a concern of every citizen, not only of scientific people. It is hard enough to get international agreement in quite simple matters, such as the perilous state of the North European fisheries, where no secrecy is involved and little national prestige, and the scientific evidence is unequivocal: but we must go on trying.

Much scientific and technical advance has led to unexpected dangers and difficulties. Without our present knowledge of bacteriology and preventive medicine, gigantic armies could never be kept in the field, and land war on the recent scale would be impossible: is medical science, therefore, to be blamed for twentieth-century war? The indiscriminate use of insecticides, by upsetting the balance of nature, can quickly do more harm than good. Radio communication may be used for spreading lies and disorder as well as truth and goodwill. Developments in microbiology, in many ways beneficent, may be used in the future for biological warfare, with effects at present unpredictable; and control by international agreement and inspection might be very difficult. The list need not be multiplied, all are aware that every new benefit to mankind provides also its own dangers, either as unexpected consequences or by deliberate misuse. Science is not alone in this: liberty may lead to licence, religion can be used to inflame passions, laws can be exploited to protect wrongdoing. If scientists feel called upon to examine their consciences, so much the better: but they need not imagine that in this they are exceptional!

It has been debated whether "the scientific mind is fundamentally amoral". The real answer is that there is no such a thing as '*the* scientific mind'. Scientists for the most part are quite ordinary folk. In their particular scientific jobs they have developed a habit of critical examination, but this does not save them from wishful thinking in ordinary affairs, or sometimes even from misrepresentation and falsehood when their emotions or prejudices are strongly enough moved. Their minds are no more amoral than those of surgeons, lawyers, or scholars. As investigators most of them realise that their function would be stultified were they to introduce moral data into a scientific argument. A surgeon is not required, or indeed allowed, to consider whether it would be better for the world if his patient died under the operation, he has only to carry it out with skill, care and integrity: but it would be foolish to conclude that the surgical mind is amoral. The surgeon himself, as a human being, has to make moral judgments: but he does so outside the operating theatre. So it is with scientific people: like all good citizens they must take account of ethical considerations, and the chief of these, as with other good citizens, are of integrity, courage and goodwill. Integrity forbids them to allow feelings of any kind to obscure facts, but that does not make them amoral: after all, integrity is the first condition of morality.

In the practical world of today, complete abandonment of secrecy in government and industry is out of the question. The advantages to international relations, and to general scientific progress, of the greatest possible freedom are evident: to these can be added the impossibility, in a free democracy, of keeping the best people unless the conditions of their work are congenial. If scientific men consistently avoid jobs which seem to them to fall short of reasonable freedom, they will force changes of organisation so that only necessary secrecy is maintained. The penalty of filling an organisation, governmental or industrial, with second-rate people, cheerfully amenable to unnecessary restrictions, is far too evident in its result on efficiency to be tolerable for long. The cure, therefore, is largely in scientists' own hands. In this, as in many other aspects of their work, moral considerations come in, and the only way to resolve the dilemma which is in so many minds is to discuss it frankly. To neglect it altogether is not amoral but immoral, it is the duty of all of us as citizens to consider the ethical basis of our work.

Today when the public importance of science and its popular esteem may turn some people's heads it is well that scientists should realise that the prestige of science is not their personal property, but a trust which they have an obligation to pass on uncompromised to their successors. The popularising of genuine science is an important public service; we should all be ready to take our part in it according to our powers: but to use the general prestige of science as a bait to attract attention to pronouncements on other topics, for example on politics or religion, is a disservice both to science and the public. As a citizen I need no more justification than any other citizen in saying what I like about such things: but I have no right to pose as a representative of science in discussing them. In the days when the representatives of religion claimed supernatural knowledge of the natural world it was necessary to insist, as Tyndall did, that the natural world belongs to science. Fortunately those days are past. If they now claim that the facts and trends of overpopulation are not what we say, we can argue about that as a scientific question: but if they insist that its consequences should be left to God, they must allow us as citizens to take the opposite view. If political pressure were applied in any way to force conformity to particular scientific theories, as happened in Germany and is happening now elsewhere, then one's right and indeed one's duty would be clear, alike as citizen and as scientist. But the nature of political institutions and the policies of political parties are not scientific questions, and how I choose to vote has nothing to do with science. Indeed, curious as it may seem, the spectrum of political opinion of scientists in Britain is much the same as that of other similar groups: though the loud-speakers are generally tuned in to one particular wave-band.

Some seventeen hundred years ago, there crystallised out, from many centuries of experience of the human problems and ethical necessities of medicine, the so-called Hippocratic Oath. The obligation of integrity and trust; the insistent claim of suffering; the care of mothers and children; solicitude for the old and weak; the sanctity of human life: these are as vital a part of medical tradition as its science and its art. Practice, it is true, may lag behind principles, but at least such failure is regarded as discreditable; and it is hard to imagine any kind of civilisation in which the ethical principles of medicine were generally disregarded. That is one reason why the future possibility of biological warfare is particularly repugnant. Today science finds itself, unexpectedly and without those centuries of tradition and experience, in a position no less important to the community than medicine: and its ethical principles have not yet clearly emerged.

Every candidate for admission to the earliest of American learned associations, was required to answer yes to the question: "Do you love truth for truth's sake, and will you endeavour impartially to find . . . it for yourself and communicate it to others?" That affirmation might have its place in a modern scientific version of the Hippocratic Oath. But again the same dilemma arises—"endeavour impartially . . . to communicate it to others". Apart altogether from considerations of national security, in many fields today much of the best research is done, and done increasingly, in industrial laboratories. Those who have seen and admired such work, and the people who do it, cannot but applaud the foresight which made it possible. But if all the results are to be communicated at once and impartially to others, could directors and shareholders be reasonably expected to continue their support? Indeed, if an industry were nationalised could it afford to give away its secrets to competitors abroad? Not in any real world in which a nation must remain solvent and industry must depend for success on the rapid application of new knowledge. The dilemma must be met by reasonable compromise, of which, perhaps,

the most hopeful sign today is that many of the directors of industry come up through research departments. A friendly and familiar contact between management and research, and between industrial and outside scientists, can reduce this particular dilemma to manageable size.

A graver problem is provided by research under government, when considerations of security come in. In the emergency which became evident in 1935, the secret development of radar for purposes of air defence aroused no obvious pangs of conscience; and many other developments come in that class. But the surest of military maxims is that counter-attack is an essential part of defence; to limit scientific methods to defensive weapons would be to ensure defeat, indeed it is quite impracticable. But let us be realists; so long as offensive weapons may be used, the part played by the scientist is no more immoral than that of the engineer, the workman, the soldier or the statesman, and the attitude of "holier-than-thou" is unbecoming. We all bear, as citizens, an equal responsibility. But is it practical to suggest that all scientists in all countries should agree, and hold to their agreement, whatever happens, to take no part in research on offensive weapons, or at least should endeavour impartially to communicate its results to others? The answer is evident. There are individuals in all free countries who find such work intolerable. In those countries their scruples are respected and they are at liberty to do something else; but let them not imagine that the problem is solved that way, or that those who think otherwise are necessarily stupid or immoral. The first condition of freedom is freedom of conscience, and the scientist has the same right to that as any citizen: but freedom does not extend to giving away other people's property, whether of goods or knowledge.

There seems to be no simple answer to the riddle. All knowledge, not only that of the natural world, can be used for evil as well as good: and in all ages there continue to be people who think that its fruit should be forbidden. Does the future welfare, therefore, of mankind depend on a refusal of science and a more intensive study of the Sermon on the Mount? There are others who hold the contrary opinion, that more and more of science and its applications alone can bring prosperity and happiness to men. Both of these extreme views seem to me entirely wrong—though the second is the more perilous, as more likely to be commonly accepted. The so-called conflict between science and religion is usually about words, too often the words of their unbalanced advocates: the reality lies somewhere in between. "Completeness and dignity", to use Tyndall's phrase, are brought to man by three main channels, first by the religious sentiment and its embodiment in ethical principles, secondly by the influence of what is beautiful in nature, human personality or art, and thirdly by the pursuit of scientific truth and its resolute use in improving human life. Some suppose that religion and beauty are incompatible: others, that the aesthetic has no relation to the scientific sense: both seem to me just as mistaken as those who hold that the scientific and the religious spirit are necessarily opposed. Co-operation is required, not conflict: for science can be used to express and apply the principles of ethics, and those principles themselves can guide the behaviour of scientific men: while the appreciation of what is good and beautiful can provide to both a vision of encouragement.

Is there really then any special ethical dilemma which we scientific men, as distinct from other people, have to meet? I think not: unless it be to convince ourselves humbly that we are just like others in having moral issues to face. It is true that integrity of thought is the absolute condition of our work, and that judgments of value must never be allowed to deflect our judgments of fact. But in this we are not unique. It is true that scientific research has opened up the possibility of unprecedented good or unlimited harm for mankind; but the use that is made of it depends in the end on the moral judgments of the whole community of men. It is totally impossible now to reverse the process of discovery: it will certainly go on. To help to guide its use aright is not a scientific dilemma, but the honourable and compelling duty of a good citizen.

Science in Industry: Survey by Manchester Research Council

THE latest annual report of the Manchester Joint Research Council tells about the survey it is making into the practice and needs of local industry in the use of scientific ideas and developments. This survey, the most ambitious project put in hand by this Research Council, aims to assemble a reliable picture of the use of science by a cross-section of industry in the north-west, and to attempt to find how scientific ideas and information could be more effectively and quickly absorbed into industrial practice. It is being carried out with the support of the D.S.I.R. Beginning in November 1950, three full-time investigators, under the general guidance of a Steering Committee of members of the Council, have carried out the first stages of the work. With the help of the Board of Trade Research Department in Manchester and Dr. Easterfield of the D.S.I.R., a group of firms was selected as representative of the range of relevant industries and of the size of industrial units in the area. An explanatory letter from the Chairman of the Council, to the Chairman or Managing Director of each firm, invited their co-operation, and in particular asked them to receive one of the investigators. The Research Council records its great satisfaction that 76% of those approached agreed to take part in the work, and adds that throughout they have been most co-operative.

The investigators, who all have long and wide industrial experience, obtained their information, under headings previously agreed, by discussion with chief executives of firms, and with their specialist experts as seemed necessary, rather than by questionnaire which has been used in previous investigations. A hundred and ninety firms, covering over 300 establishments, have so far been visited in this way. As establishments employing fewer than fifty persons were excluded from the main investigation and the investigation deals only with production (excluding agriculture, mining, clothing and building) and not with services, this number represents some 10% of the relevant establishments in the area covered. The majority of these are concerned with chemicals, mechanical engineering, electrical engineering, textile manufacturing and textile finishing, but the sample has been chosen to include a groups of other, smaller, industries. It has been made clear that the anonymity of firms co-operating will be fully respected in the consideration of the information and comment gathered by the investigators, as well as in the final report.

The information which has been collected includes the following: scientific qualifications of directors and staff; recruitment, training and encouragement of scientific and technical staff; organisation for research and development; use of research associations; contact with universities and technical colleges; use of and familiarity with sources of scientific information, including library and information services and consultants; attitude to sponsored research and the National Research Development Corporation (the Government agency which was established with the aim of developing neglected inventions); the limitation of development by factors involving finance, supply of materials and pressure for current production.

The opportunity has been taken to reciprocate the co-operation of firms, by incidental help with their problems when practicable.

The information obtained from the first 100 firms has been reviewed by the Research Council and further advice has been sought on the next stage of the work, particularly on the steps necessary to bring out the significant factors which really determine the use of scientific ideas and developments by a firm or an industry.

(*Left*).—Setterwort, *Helleborus foetidus*. One of the few flowering plants that can live in the dense shade of chalk beechwoods; it is able to survive in this habitat as it takes full advantage of the period when the trees are bare. (*Right*).—Juniper, *Juniperus communis*. This conifer is a characteristic shrub of many downs.

(*Left*).—Ground Pine, *Ajuga chamaepitys*. So called because it looks like a dwarf conifer. Actually it is a member of the Dead Nettle family (Labiatae). A chalk plant which is quite common on the Continent, this yellow-flowered annual is a rare species in Britain. (*Right*).—The Chalk Violet, *Viola hirta*. This species of violet, which is characteristic of the chalk scrub, can be recognised from its dull-blue, scentless flowers and its very hairy, heart-shaped leaves. (*The first three photos, and the last four in this article, are by W. H. Spreadbury; the rest come from Sir Edward Salisbury's book.*)

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First plants to colonise bare chalk are blue-green algae and mosses, which create a thin soil capable of supporting flowering plants. Chalk grassland is first established; this may be succeeded by chalk scrub, which in turn can be replaced—by woodland. These three stages in the plant succession characteristic of chalk are seen in the photograph. In the foreground there is chalk pasture; in the middle distance, chalk scrub; on the brow of the slope, a beech hanger has developed.

Flowers of the Chalk

ECOLOGY—the branch of biology which deals with the mutual relations between organisms and their environment—is a remarkably modern study in spite of the fact that its origins can be traced as far back as Linnaeus, while some primitive ecological ideas were set down on paper even before the Swedish botanist's two important papers *Politia naturae* and *Oeconomia naturae* made their appearance. All the major principles of ecology have been elucidated and published well within living memory. One of the pioneers of British plant ecology, Sir Arthur Tansley, is, happily, still with us, and another—Prof. F. W. Oliver of University College, London—died only very recently. The latter believed that botany could only be taught through study of the *living* plant, and he encouraged his students to apply the discoveries derived from new sciences such as plant physiology and soil science to their field studies, establishing for this purpose a field station on Blakeney Point which was the prototype of the modern 'field study centres' now recognised as essential in the teaching of the modern dynamic concepts of biology.

One of Oliver's students was E. J. Salisbury, who has been a keen ecologist ever since those early days at University College. Almost the first thing which Sir Edward Salisbury organised when he took over the directorship of Kew Gardens was the planting of a chalk garden, which reflects his lifelong ecological interest in downland plants. Sir Edward's home has always been in Chiltern country, and it is therefore no surprise to find that a large part of the ecological monograph which he has just published is devoted to the ecology of chalk plants.* Anyone with a scientific interest in the plants which occupy the limestone areas of Britain and the coastal dunes will find this book most instructive, for it relates the distribution of these two distinctive types of vegetation to the complex of environmental factors which can only be unravelled if one draws upon the ideas developed by scientists working in such different fields as plant physiology and soil physics.

The principal feature of downland vegetation which comes to mind when one thinks of, say, the South Downs or the Chiltern Hills is the close-cropped springy green turf, and the flowers of such characteristic chalk plants as rampion, scabious, rock rose, cathartic flax and orchids. A little thought about this very distinctive vegetation and one starts asking questions such as: Why are these particular plants so successful in chalk areas? In what way are they specially adapted to this particular environment? What environmental factors favour these plants to the virtual exclusion of other species? These are the kind of questions to which answers are provided in Salisbury's new book.

The ecologist, when he is considering a particular piece of territory, looks for the environmental factors which affect plant growth and so influence the nature of the community of plants which come to occupy that particular stretch of countryside. These factors fall into three main groups, which are, (1) climatic; (2) physiographic; (3) biotic. The physiographic factors result from topographic and soil conditions; the biotic factors are those connected with the vital activities of animals (here the ecologist includes man) and the plants themselves.

The biotic factors are all-important in the case of the chalk downs. Originally it seems that they were covered with woods—mainly of oak and hazel. Then there was a change in climate, which became warmer and drier and was followed by the invasion of well-drained chalkland by beech. (The beech tree reached Britain from the Continent about 3000 years ago.) The landscape began to change again when Bronze Age man began to fell the trees and shrubs to make room for his primitive crops and his animals, and to obtain supplies of fuel. During this time the climate was steadily becoming drier and the water table in the chalk was falling, with the result that the timber line receded "like a falling tide", to quote Salisbury's graphic phrase. The Downs were trending towards their modern condition. The decisive biotic factor which gave them their most distinctive character was the introduction of sheep farming. In Salisbury's words: "It has been the grazing over the centuries that in no small degree has imposed upon the downland turf its superficial uniformity and the prevalence of low-growing herbs that only attain any appreciable stature at the time of flowering. The Downs thus share something of that beauty that Bacon admired in 'lawns of green grass kept finely shorn'; but their aesthetic appeal is due in large measure to the open unconfined character and their unique topography. . . . Man and sheep have combined to ensure 'the round bosom of the windswept wold' and this is as potent a factor in their wild life as the physical and chemical features of the soil and one which must be fully appreciated if the attractions and amenities of the Downs are to be preserved."

Which particular plants of downland can flourish in spite of constant close cropping by sheep? First of all one finds two

* *Downs and Dunes.* (London, G. Bell & Sons Ltd., 1952, 328 pp., 45*s*.)

(*Left*).—CHICORY (*Cichorium intybus*), a Composite with sky-blue flowers, usually borne in pairs; the root provides the chicory of commerce, used as a coffee substitute. (*Right*).—RAMPION (*Phyteuma tenerum*), a very characteristic chalk species. Its deep-blue heads are composed of many small flowers whose long curved styles are most conspicuous. Very common on Sussex Downs.

species of grass which have this capacity, and which are also drought-resistant. The first of these is appropriately called Sheep's Fescue (*Festuca ovina*), and the other is Red Fescue (*Festuca rubra*). Both have fine wiry leaves which are adapted to life in dry situations; under drought conditions the two halves of the leaf blade, which are hinged together to form a 'V', close up on each other so that the stomata are no longer directly exposed to the atmosphere, with the result that the rate at which water vapour is lost by transpiration is considerably reduced.

The majority of chalk plants are low-growing herbs which fall into two categories, namely *rosette* plants, and *mat* plants (of which Thyme is typical).

Typical rosette plants, which are plants in which the stem is extremely reduced so that the leaves are crowded together to form a flat rosette, include the following: Chalk Scabious, Chalk Ragwort, Grey Plantain (*Plantago media*), Rampion, Cotton Thistle, Dwarf Thistle (*Cirsium acaulos*), Carline Thistle.

In this category belong the orchids, which are essentially rosette plants except when they come into flower. Characteristic chalk species of orchids which Salisbury lists in his book are as follows: Man Orchid, Pyramidal, Sweet-scented (*Gymnadenia conopsea*), Musk, Lizard, Bee, Spider, Soldier, Monkey, and the Dwarf Orchid (*Orchis ustulata*). Only about fifty species of orchids are to be found in Britain altogether, so it will be realised that the chalk flora is relatively rich in orchids.

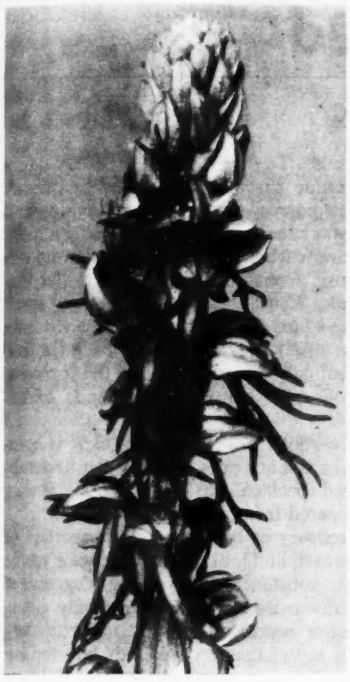
Typical mat plants. Thyme has already been mentioned as an example of a chalk plant which grows along the ground to form a mat of vegetation. Other chalk plants with this habit are: Squinancy-wort (*Asperula cynchica*), Milk Vetch, Horseshoe Vetch, Rock Rose, Chalk Milkwort (*Polygala calcarea*).

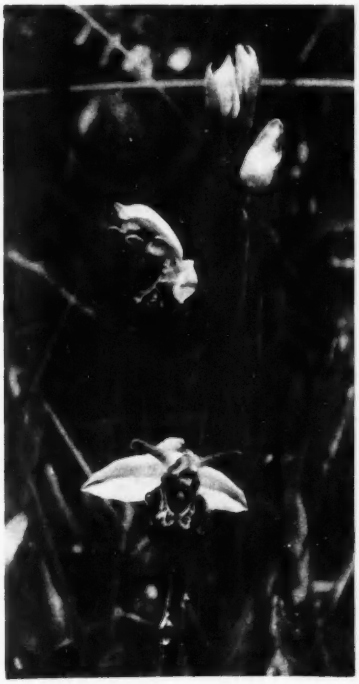
Once established all these plants are hard to dislodge. The rosette plants, for instance, have a remarkable capacity for smothering competitors; their leaves exert a definite downward pressure quite strong enough to thwart the growth of seedling intruders. (This pressure can be demonstrated by cutting through the stem below the rosette of leaves, when the leaves will be found to bend downwards vigorously.) A downland sward is a closely packed community of plants with very little space between them, which makes it hard for new seedlings to get established in this habitat, and it is scarcely surprising, therefore, to find that annual and biennial species are not strongly represented in the downland flora.

For the characteristic downland flowers to maintain themselves indefinitely in face of invading plants does require, however, the continuance of grazing. Chalk grassland tends to become chalk scrub eventually in the absence of sheep, and finally the ground becomes covered with beechwood.

What happens to such downland if it is ploughed up, as has happened in various places during the two World Wars? This question is answered in Salisbury's book. He quotes the case of a downland area which was ploughed up about 1900, and which has remained derelict for nearly fifty years. At first, says Salisbury, the erstwhile arable land was colonised by grasses and Wild Strawberry; where the vegetation remained more open, cornfield weeds persisted for some years. Soon, however, young hawthorns, dog roses, dogwood, spindle and other shrubs appeared, to form a very open scrub. In the shelter of this scrub, which gave protection from browsing animals, plants characteristic of wood margins and hedgerows became established so that thirty-five years after cultivation ceased, no less than 125 different species of flowering plants were found by Salisbury growing on this area. "After the lapse of fifty years much of the area had almost attained the status of woodland, with a marked increase of the more shade-loving species and a diminution over most of the area of the light-demanding species, now driven to the better illuminated periphery of the sides of trackways," Salisbury comments.

So much for the influence of the biotic factors. What of the *soil* factors? When one starts investigating the soil of a chalk area one must be prepared to expect some surprises; for example, one must not be surprised on rare occasions to find plants like heather growing in a chalk area, which is against all the rules. A mature chalk soil is very different chemically and physically from plain chalk rock. A vertical section through such a soil





CHALK ORCHIDS. (*Left*).—MAN ORCHID; the bottom petal (lip or labellum) has four lobes that look like the two arms and legs of a small human figure. Almost invariably found on lime-rich soils. (*Centre*).—BEE ORCHID; the lip is round, fat and reddish-brown, resembling a bumble bee. Commonest on chalky soils. (*Right*).—LIZARD ORCHID; the greyish-purple-green flowers have a shape suggestive of a lizard, the trilobed lip supplying the two 'hind legs' and the tail. Britain's largest orchid (18 in. tall), it is rare, and is found almost exclusively on chalk and limestone.

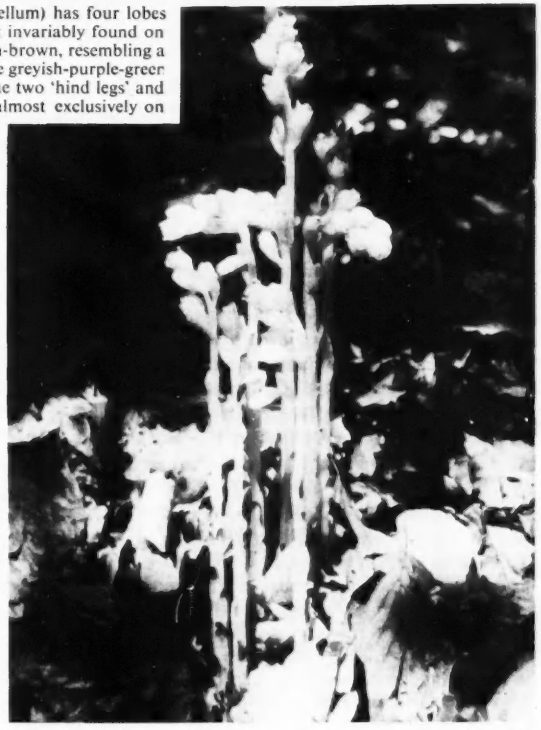
shows several zones. Near the surface the soil is rich in organic matter, which holds a fair amount of moisture; this applies to the top two or three inches. The deeper one goes the less organic matter one finds, and the moisture content tends to be reduced, until one reaches a point of maximum dryness about a foot down.

Below that the chalk content increases steadily until eventually solid chalk is reached; in this zone the moisture content tends to increase with depth, until at about 20 inches below the surface there is plenty of water.

Many of the chalk plants are shallow rooted and rely on the top two or three inches of soil for their water supply. There are a few plants, such as the Salad Burnet, which tap water from that level and also from the bottom zone of soil; in such plants one therefore finds two sets of bushy side roots connected by a stretch of tap root which is almost bereft of lateral fibres!

The top soil on chalkland may in fact contain very little chalk. This is due to the fact that chalk is quite easily dissolved by water containing carbon dioxide in quantity, as soil water may do. Chalk thus tends to be leached out from the soil near the surface where there is plenty of root action (and respiring roots release carbon dioxide) and dead organic matter is decomposing and liberating carbon dioxide. The stage can be reached when all the chalk has been dissolved out, and the soil comes to have a *p*H of 5 or less, when acid-loving plants like heather can become established.

The presence of chalk can strongly affect the capacity of plants to absorb particular chemical elements. Absorption of potassium and phosphorus, for example, is reduced. The same applies to iron, manganese and boron. Lack of the last three elements can cause marked mineral-deficiency diseases, such as heart rot of sugar beet and grey speck of oats, as farmers who cultivate chalklands know to their cost, though science has shown them how to correct these deficiency diseases. In this respect, therefore, the chalk plants are better fitted physiologically to occupy this type of habitat than are man's crop plants with their more specialised requirements for mineral nutrients.



Typical chalk beechwood lacks ground vegetation except for a few orchids and Yellow Bird's Nest (*Monotropa hypopitys*), shown here; this near relative of the heaths lives saprophytically with aid of mycorrhiza.

Germs Defeated

R. W. RICHARDS, B.Pharm., Ph.C.

Most of us today are apt to regard undergoing a minor operation as a safe undertaking—often painful and worrying but certainly not hazardous, and the chance of not surviving it never crosses the mind. One is, therefore, rather prone to overlook the fact that a hundred years ago things were very different. In those days the mortality rate amongst the luckless patients after quite small surgical proceedings was lamentably high; a state of affairs which was due principally to the complete lack of knowledge of wound infections and of the nature of sepsis brought about by bacterial contamination.

When it is considered that the surgeon of those times, his operating coat stiffened with dried blood and with his suture needles stuck through his lapels, often came straight from the dissecting room with dirty hands to operate on a patient, we need not wonder that such deplorable circumstances existed. That so many patients died from septicaemia, having undergone operations of one sort or another, was more or less taken for granted, so that it is not altogether surprising that when the first attempt was made to introduce some degree of what we know today as antisepsis into a hospital, it was openly ignored and the originator regarded as a heretic. This was the tragic story of Ignace Phillipe Semmelweiss (1818–65), the man who proved his theory and yet was not believed by his medical colleagues. Semmelweiss was a Hungarian obstetrician and in the course of his work he came across only too often the highly infectious and frequently fatal childbed or puerperal fever. He believed that this complaint was transmitted from patient to patient by the doctors themselves, and suggested as a means of prevention that they should wash their hands with chloride of lime before attending to their charges. Since bacteria were not then known to exist, Semmelweiss put down the cause of the disease to what he called a decomposing animal substance. But despite the very obvious fall in the maternal mortality rate few of his medical colleagues would acknowledge his achievement. For years he struggled for recognition and eventually, much maligned and discredited, he died a broken man in a lunatic asylum—by one of those strange twists of fate, of septicaemia, the very type of disease he had shown the medical profession a way to prevent.

Lister's Antiseptic Surgery

Semmelweiss died in 1865, a significant year, for it was then that the attention of Joseph Lister, the Essex-born professor of surgery at Glasgow University, was drawn to the research which was being carried out by his French contemporary, Louis Pasteur, into the nature and causes of putrefaction and fermentation. Basing his assumptions on Pasteur's work, Lister formed the opinion that suppurations from wounds might be due to infection by bacteria. It may be added that Lister was in no way influenced by the work of Semmelweiss of which he had no knowledge at the time.

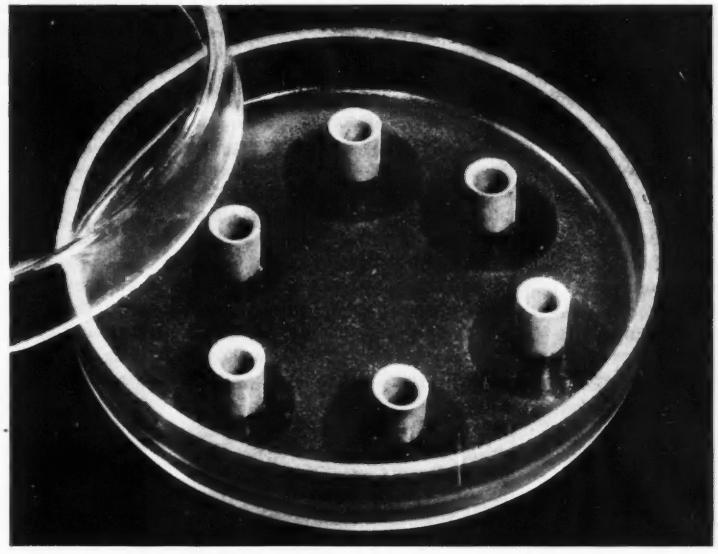
Lister already knew that carbolic acid had antiputrefactive properties and so he decided to make use of it for dressing open wounds. To begin with, he used a very strong solution of crude carbolic acid and consequently found that, due to its corrosive properties, sloughing and death of the tissues was caused. However, by using a more dilute solution of purer carbolic acid he found that he was able to prevent sepsis from occurring. The initial discovery had been made. Lister even went so far as to spray the air above the site of an operation continuously during actual operations in order to kill airborne bacteria, but this practice was eventually discarded, due to the corrosive action of the carbolic acid spray on the hands of the surgeon.

It is therefore to carbolic acid, or phenol as it is commonly called, that the honour goes to being the first substance to be employed specifically as an antiseptic. It was, by the way, first prepared from coal tar in 1843.

Following the discovery of the antiseptic properties of phenol, progress was fast, and looking back we see a whole legion of antiseptic substances of varying degrees of activity, many now discarded and others gradually giving way to new and better preparations. But unfortunately along with the discovery of these compounds has come a vocabulary of terms, which is, to say the least of it, extensive and more than a little involved. Many of these terms are used loosely, but during recent years they have been given more precise interpretations. To dwell for a moment on some of the more commonly used of these terms the three which come to mind first of all are 'antiseptic', 'disinfectant', and 'germicide'. 'Disinfectant' and 'germicide' are usually taken to mean the same thing: that is, they both *kill* micro-organisms; whereas 'antiseptic' is, by definition, a substance which will *arrest the growth* of organisms causing sepsis without necessarily killing them. Theoretically, if the antiseptic is washed away the organisms will commence to grow again, and this is exactly what happens. Generally speaking, the relationship between antiseptics and disinfectants or germicides is merely one of degree, the latter, when used in a dilute form, usually assuming the properties of antiseptics.

In recent years the term 'antibiotic' has figured prominently in medical and scientific writings generally, as a result of the discovery of penicillin. The term 'antibiotic' derives from the word 'antibiosis', which was coined as long ago as 1889 by Vuillemin. He used it to cover the kind of situation in which one organism destroys the life of a different species in order to survive; the following passage gives the exact context in which he first used it:

> "The lion that springs on its prey and the serpent that poisons the wound before devouring its victim are not considered to be parasites. There is nothing equivocal about it—one creature destroys the life of another in order to sustain its own, the first being entirely active and the second entirely passive; one is in unrestricted opposition to the life of the other. The condition is so simple that it has never been named, but instead of being examined in isolation it can be viewed as a factor



Antibiosis is the antagonism of one organism for another. Where this effect leads to suppression of pathogenic bacteria and is due to a chemical, which is non-toxic to humans and can be isolated, one has an antibiotic with medical potentialities as an internal antiseptic. The classic example is penicillin, the antibiotic principle of the mould *Penicillium notatum*, here seen suppressing the growth of *Bacillus subtilis*; the cylinders contain penicillin solutions of varying strength, and around them are clear areas where the penicillin has stopped bacterial growth.

in more complex phenomena. For simplicity we shall refer to it as *antibiosis*; the active participant will be the *antibiote*."

It was after the discovery of penicillin that the term 'antibiotic' became established in the literature. This has been defined as an "anti-infective agent of biological origin", which would include substances such as lysozyme as well as antibiotics of microbial origin such as penicillin. A more restricted definition, which preserves the concept of competition between two species of organisms leading to the suppression of one of them, is that offered by Sir Howard Florey in these words: "an antibiotic is a chemical substance produced by a micro-organism which interferes with the growth of other micro-organisms".

'Anti-bacterial', though perhaps less well known, is worthy of mention in view of its increasing use; this covers every substance, be it antiseptic, germicide, or antibiotic, which is inimical to the growth of bacteria but it does not, of course, attempt distinction between the killing of bacteria and the mere arresting of growth. That distinction is supplied by the simple expedient which depends on the addition of the suffixes *-cide* and *-static* to various nouns; thus we get 'bactericide' and 'bacteriostatic', in the case of bacteria, 'fungicide' and 'fungistatic' where moulds are involved, and many others, too, like *viricide* and *trypanocide*. It may also be added that 'anti-mycotic' is analogous to 'anti-bacterial' in the field of mycology. The use of the word 'preservative' in many cases often implies a substance which inhibits the growth of bacteria and other micro-organisms, and this is particularly interesting, because apart from the conventional disinfectants and mild antiseptics like boric acid, cane sugar is included in this category. The reason for this is that in such confections as jam and syrups, where the concentration of sugar is high, the osmotic pressure of the strong sugar solution is greater than that of the micro-organisms, with the result that they are unable to thrive. On the other hand, weak solutions of sugar will, of course, ferment readily—as sometimes happens with home-made jams.

Like a good many other drugs introduced into medicine on a purely empirical basis before their mode of action was known, antiseptic and germicidal substances have a very long history. The embalmers of ancient Egypt found spices, gums and vegetable oils to be excellent preservatives, as the present-day state of their mummies testifies. The origin of salting, spicing and smoking are lost in the mists of time, and the use of wine and vinegar for dressing wounds can be traced back at least as far as Hippocrates. The burning of aromatic substances and sulphur was used to combat the spread of the bubonic plague in the Middle Ages, while about that time Friar's Balsam became a very popular remedy for dressing wounds, its healing properties being due to the acids of the constituent balsams from which it was prepared. But until Lister's fundamental discovery there was no rationale for the use of such substances.

It was not long before the antiseptic surgery of Lister was on its way out. From the work of the eminent German bacteriologist Robert Koch (1842–1910), it soon became apparent that the most important and obvious thing to do during operations was to exclude bacteria from wounds altogether, thus giving rise to the highly specialised technique which we call today 'aseptic' surgery. But do not suppose that this in any way detracts from the value of antiseptics and disinfectants. In fact it rather adds to their importance. The essential requirement that an operating theatre itself must be sterile, or as near sterile as possible, has made the employment of potent disinfectant substances a virtual necessity, and while the use of steam and dry heat for sterilisation purposes is no doubt preferable for dressings and instruments, these are not particularly versatile processes and disinfectants still have a well-recognised place to fill; wound and skin sterilisation are among their most important applications.

Since Lister's time, we have progressed a long way. The popular misconception that a potent disinfectant must be intensely poisonous has long since been refuted, and today modern antiseptics and germicides are not only practically innocuous to human beings but they are far more active against bacteria than any of their predecessors were.

Carbolic acid is still widely used. In a crude form it is made into rather strong-smelling emulsions which are known collectively as 'black fluids' and used for the disinfection of drains, cess-pits, etc.; they are cheap and effective, but are of little use for anything else. A more refined type of this preparation called 'white fluid' was introduced some years ago for use in bathing wounds and general hygiene, but in the face of competition from more modern preparations it is tending to be less and less used. (It is interesting to note that phenol *emulsions* have been shown to have a greater germicidal power than simple watery solutions alone.)

Cresol and Xylenol

Besides phenol, there are several compounds among the hundred and twenty or so substances present in coal tar, which are better antiseptics than phenol itself; these substances were present in the crude tar extracts used originally for antiseptic purposes. Chief among them is a series of three chemical substances called the *cresols*, which resemble phenol to some extent in chemical structure; there is also another group called the *xylenols*. In this group, too, there are three separate substances.

These two groups, and particularly certain derivatives of some of their members, are highly active anti-bacterial compounds. The well-known preparation we know as Lysol is a 50% solution of commercial cresol (i.e. a mixture of the three cresols) in a soap solution, and it is still in common use for many purposes. It may seem strange to use soap solution as a vehicle, but this is necessary because commercial cresol, which is a liquid not particularly miscible with water, can be made to mix with water well, even at ordinary temperatures, by the addition of soap.

Lysol, because of its cresol content, is not only poisonous but also corrosive, when applied neat. This limits its uses, but in spite of these drawbacks it is a very effective preparation for many purposes.

It has already been mentioned that commercial cresol is a mixture of three cresols; these are called, respectively, *ortho-*, *para-* and *meta*-cresol depending on the relative position of the two substituent groups in the molecule. The last-mentioned compound gives rise on chlorination to a substance with considerable anti-bacterial activity, and this is known as parachlormetacresol; usually it is known as chlorcresol, or by the initials PCMC. In medicine chlorcresol finds one special application as it provides a convenient means of sterilising solutions of thermolabile (heat-sensitive) substances which are intended for injection. It is essential, of course, that these be free from all living bacteria; ordinarily, autoclaving in a sealed container is the most effective way of sterilising solutions, but where this method causes decomposition of the medicaments involved (owing to the high autoclave temperature, which is 115°C.) chlorcresol is added and sterilisation is effected by heating to only 100°C. The relatively non-toxic nature of chlorcresol and the high activity of its dilute solution make it invaluable in this connexion; sterilisation by this method makes it possible in 30 minutes not only to kill the vegetative forms of bacteria, but the stubbornly resistant spores as well, many of which can survive boiling at 100°C. for a considerable time.

Chlorxylenol

The advent of the more powerful PCMX or parachlormetaxylenol (chlorxylenol) has done much to popularise the so-called non-poisonous antiseptics. This is an odourless and potent derivative of metaxylenol (one of the three xylenols mentioned earlier), which has made possible the formulation of pleasantly perfumed antiseptic products suitable for all domestic and hospital purposes. As chlorxylenol itself is rather insoluble in water, a soap is again incorporated into the preparation to facilitate its solution. Most commonly it is perfumed with terpineol (the active principle of the oil of the Australian ti-tree, *Melaleuca alternifolia*, which itself has antiseptic properties), the result being a golden-yellow viscous liquid; this type of preparation first made its public appearance as 'Dettol'. It is no exaggeration to say that today every hospital in this country uses chlorxylenol antiseptics for one purpose or another. They are neither poisonous nor corrosive, but, if swallowed, are naturally apt to be somewhat disagreeable. Many products of a similar type are available at the present time and there is no doubt that they represent the commonest type of antiseptic in use.

Apart from the disinfectant preparations already mentioned, reference books contain details of many other substances which used to be in favour as antiseptics, but which became obsolete for this purpose. In fact, the story of antiseptics is full of vogues which have waxed and waned. Among the commonest compounds still used as antiseptics but now growing out of fashion are iodine and its compounds, hydrogen peroxide, chlorine compounds (hypochlorites, in particular), formaldehyde, mercury derivatives and alcohol; all of these at one time enjoyed wide popularity and usage.

Iodine is particularly interesting. This chemical element was first discovered by Courtois in 1811, although ninety years were to elapse before it was first advocated as an antiseptic. It tends to be little used for this purpose nowadays, however, because of its somewhat irritant action on the skin. Nevertheless, iodine is important due to the fact that it is practically the only chemical available with which it is possible to effect the successful large-scale sterilisation of catgut and other similar surgical suture materials. Catgut is prepared from the muscular coat of the intestine of the sheep; as would be expected, it is initially contaminated with bacteria, which abound in the sheep's gut. During the process of twisting into strings these organisms become literally locked in the tissues; because of the nature of the material it cannot be sterilised by boiling with any aqueous liquid. However, by immersing it in a solution of iodine (in potassium iodide) for a period of about ten days, and then removing the iodine which it has absorbed by washing with sterile solution of sodium thiosulphate, sterility is obtained.

Both hydrogen peroxide and chlorine exert their germicidal effects by their liberation of nascent oxygen; decomposition of the hydrogen peroxide yields nascent oxygen directly, while chlorine (which itself has some *direct* disinfecting action) combines with water molecules to produce hypochlorous acid, which then breaks down with the release of nascent oxygen. During the 1914–18 war, hypochlorite preparations such as Dakin's solution were used extensively.

Most readers will be familiar with the antiseptic properties of alcohol. Seventy per cent alcohol, for instance, is still fairly commonly employed by doctors and surgeons as a convenient medium in which to store surgical instruments; it has the advantage here that it is not conducive to rust formation. It is somewhat surprising to find that pure or absolute alcohol, on the other hand, is devoid of antiseptic properties, which only appear on the addition of water; with 30% of water present the solution exerts its maximum antiseptic effect.

Quaternary Ammonium Antiseptics

Research is still proceeding in the antiseptic field. In more recent years a new group of antiseptic substances has made its appearance, members of which to some extent break with convention. Because of their particular type of chemical constitution, these highly potent compounds are known as quaternary ammonium antiseptics, and there are several available in this country at the present time. The three best known are Cetrimide, Domiphen Bromide and Benzalkonium Chloride. They are unconventional in the sense that they are usually used in very weak odourless solutions; Domiphen Bromide is, for example, in some cases quite effective at a dilution of 1 part in 10,000, and there is some prejudice, especially among the laity, against an antiseptic solution of this type which appears to be little more than pure water. This factor explains to some extent why these antiseptics have not come into wider use.

It was Domagk, pioneer in the sulpha-drug field, who discovered the first quaternary ammonium antiseptic in 1935, which indicates the relatively long period of time which it has taken for this group to come into favour. The war was partly responsible for retarding their development, although the early 1940s saw a good deal of American work in this field.

The original German antiseptic called 'Zephiran', which was available over ten years ago, recently reappeared in Britain; known as 'Roccal' it contains Benzalkonium Chloride, and is somewhat less pure than 'Zephiran' as originally marketed by the Germans.

For several years now Cetrimide (CTAB), a substance evolved in the laboratories of Imperial Chemical Industries and marketed as 'Cetavlon', has been used in hospitals, and there is no doubt that this type of preparation has come to stay.

Briefly, the 'quats', as they are called colloquially, can be considered to be derivatives of ammonium hydroxide (NH_4OH), in which the four hydrogen atoms are replaced by other groups while the hydroxyl radicle is substituted by a halogen, often bromine. Thus the chemical name for the most potent member of the group, Domiphen Bromide, is β-phenoxy-ethyl-dimethyl-dodecyl ammonium bromide, and this clearly indicates the various groupings which replace the hydrogen atoms and hydroxyl radicle. This particular compound is marketed under the name 'Bradosol'. Their chemical structure confers on these substances the property of detergency, and this surface activity enhances their antiseptic action. Some idea of the amount of research that is being put into these compounds can be gained by the fact that a recent American book on the subject—*Surface-Active Quaternary Ammonium Germicides*, by Lawrence, published in 1950 by Academic Press of New York—gives a bibliography of over 500 references. Their potentialities are considerable, especially as their detergent properties render them useful in fields far away from straight medicine—for example, in the food industries where they can be used for washing dairy and other food equipment.

There are so many antiseptics and disinfectants that readers will appreciate the need for a good method of comparing their relative efficiencies. This need was felt soon after antiseptics first began to be used, particularly when attention was being directed to the possibility of using substances other than phenol. In 1903, the famous Rideal-Walker test came into being, though this is no longer considered to be of great value in actual practice. Devised by Dr. Samuel Rideal and his chemist collaborator, J. T. Ainslie Walker, the purpose of this test was to ascertain what is known as the *phenol coefficient* of a disinfectant; in other words, comparing its effectiveness with that of Phenol and expressing the result as a number. Phenol, being easily obtainable in a pure state, and known to have well-defined antiseptic properties, was the obvious choice as a standard. The essentials of the test are briefly these.* Suitable dilutions of phenol and the test substance are allowed to act separately in test tubes under exactly similar conditions with *Bacterium typhosum*; at intervals of 2½ minutes a loopful of each dilution is transferred (on a platinum loop similar to that used in chemical analysis) to a sterile liquid culture medium, which itself is then incubated. Bacterial growth in the medium, which makes itself visible to the naked eye because the liquid medium becomes cloudy, shows which particular dilutions of antiseptic were *not* effective against the test organism in the time allowed (i.e. 2½, 5, 7½ or 10 minutes). By repeating the test several times until a suitable dilution is found at which growth of the bacterium is suppressed, and then dividing the figure for the dilution by the figure expressing the dilution of phenol which just prevents growth, gives the Rideal-Walker coefficient of the substance. Typical Rideal-Walker coefficients of commonly used antiseptics are given in the table overleaf.

The main objection to the Rideal-Walker test is that it does not reproduce conditions similar to those involved when antiseptics are used practically. For example, antiseptics in medical use tend often to lose potency in the presence of protein materials, e.g. pus and blood plasma, with which they combine; this is obviously an important factor where the dressing of wounds needs to be considered. Formaldehyde and chlorine are particularly bad offenders in this respect.

In order to allow for this, Dr. Harriet Chick (now Dame

* Full details of the Rideal-Walker test are given in British Standard Specification No. 541.

TABLE SHOWING THE R.-W. VALUES OF SOME COMMON ANTISEPTIC SUBSTANCES

Antiseptic	*Rideal-Walker Coefficient*
PHENOL	1
CHLORCRESOL	13·3
CHLORXYLENOL	36
AMYLMETACRESOL	250
'CRESANTOL 3'	105
'DETTOL'	3
'BRADOSOL'	450
CTAB	210
TYPICAL BLACK FLUID	11

Harriet Chick) and Sir Charles Martin, who were working at the Lister Institute, put forward in 1908 their suggestions for the test which perpetuates their name. The Chick-Martin test is basically the same as the Rideal-Walker, but is carried out in the presence of protein. Originally, the protein material decided upon was dried faeces, but in 1934 Garrod advocated its replacement by yeast, pointing out that because of its cellular nature it would nearly reproduce practical conditions of antiseptic usage. The British Standards Institution have now adopted this modification, and their standard specification for the test sets out the full details of how it should be carried out.* Standardised technique is particularly important here, since different protein materials and different test organisms can give rise to considerable variation in results.

So far, the substances mentioned have been for external use, and have been non-selective in their action, that is to say, they have some action against all bacteria. Nevertheless, there are many highly active chemical substances which can be given internally and which act on certain organisms only. They are selective in their action. Prominent among these are certain dyes (usually, however, these are used *externally*), the sulpha drugs and, of course, penicillin and the other antibiotics.

The two best-known antiseptic dyestuffs are *Acriflavine* and *Proflavine*, but Gentian Violet and Brilliant Green are also in fairly common use. Anyone who has experienced the use of any of these substances in actual practice can well testify to their propensity for staining. Acriflavine was introduced towards the end of the 1914–18 war; it proved a very useful dressing for wounds, being an effective antiseptic which does little damage to body tissues. It has largely given way to proflavine, although this in its turn is to some extent being supplanted by one of its non-staining chemical relatives known as *aminacrin*.

It was as a result of the work with antiseptic dyes that one of the most important advances in the whole of medicine came to be made, an advance which turned the course of medical treatment into channels where never before had it been possible to explore. When Gerhard Domagk in 1932* first found that a derivative of the azo-dyestuff chrysoidin, a compound later to be called 'Prontosil Rubrum', possessed the unpredecented property of keeping alive mice experimentally infected with streptococci—the first antiseptic drug which was effective actually in the body itself had been discovered. From these tests on mice, the use of the drug spread to human patients suffering from various infections, and the subsequent realisation by chemists of the Pasteur Institute that 'Prontosil Rubrum' owed its then remarkable properties to the fact that it was broken down in the body to para-aminobenzene sulphonamide, a relatively simple compound, served to centre attention on a substance which had already been known for well over twenty years or more. It was given the name 'sulphanilamide' and, besides being used clinically itself, from it were derived a whole host of compounds which we now call the sulphonamides or sulpha drugs. Thus it became possible to cure such diseases as pneumonia and septicaemia which had hitherto been frequently fatal, and which at best could be only treated with relatively ineffective drugs, the patients own natural resistance being largely instrumental in bringing about a cure. Together with their later companions in medicine, penicillin and the other antibiotics, a formidable array of substances for fighting disease is presented. Certain of the hitherto unassailable virus diseases will now succumb to antibiotic therapy, but we must still resign ourselves to the fact that they are selective. The tubercle bacillus, for example, is not susceptible and still defies all attempts to attack it, and even para-aminosalicylic acid, streptomycin, the thiosemicarbazones,† and the very recent isonicotinic hydrazide although very valuable, cannot be called specific.

The tubercle bacillus is by no means the only organism against which there is, as yet, no completely effective remedy. A moment's reflection will bring to mind many diseases for which at the present time there is no known cure, although there can be little doubt that the time will come when all harmful bacteria will be eradicated.

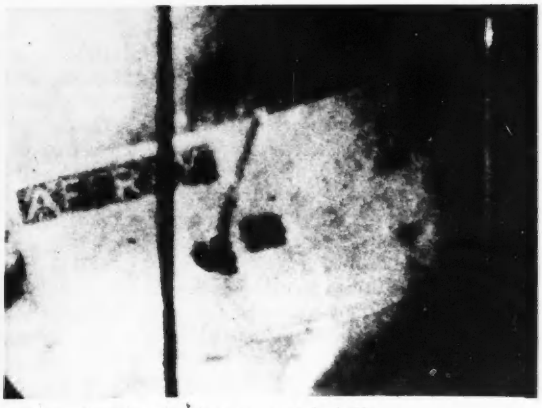
It has not been possible to cover all aspects of the field. No mention has been made of the manner by which anti-bacterial substances exert their effect. Indeed, this in itself demands a whole article. Nor has any reference been made to the so-called physical germicides, i.e. ultra-violet light, heat and ultrasonic sound waves.

Nevertheless, it is hoped that the idea has been conveyed not only of the paramount importance of anti-bacterial substances in medicine, but how completely they are today taken for granted.

* "Modified Technique of the Chick-Martin Test for Disinfectants." B.S.S. No. 808, 1938.

* The extraordinary circumstances under which Domagk was forced to decline the 1939 Nobel Prize for Medicine for this discovery were reviewed in DISCOVERY recently (Vol. 12, 136, May 1951).

† The thiosemicarbazones are a group of drugs which have been introduced into medicine recently for the treatment of tuberculosis. It is interesting to note that the original research into the nature of these compounds was first undertaken by Domagk. Briefly, they are thiosemicarbazone derivatives of aldehydes and the one which has received the most attention at the present time is that which has been called Thiacetazone. They show considerable promise, although it is probably too early to predict what their clinical future is likely to be.



Two historic snapshots of the *Affray* obtained by photographing the television screen on the bridge of the search vessel. FIG. 1 (*left*).—This television view identified the wreck; the star-shaped radar array was the vital clue. FIG. 2 (*right*).—Afterwards the camera was used to find the vessel's name-plate, of which this is the first view the watchers obtained on the television screen.

Underwater Television

W. R. STAMP, B.Sc.
Admiralty Research Laboratory

THE conception of remote underwater vision dates almost from the realisation of television itself. The underwater world having been the stronghold of the privileged few—divers and expert swimmers—much mystery has always surrounded it. This has been dispelled to some extent in recent years by underwater cine-photography, notably by the Groupe Recherches Sousmarines of the French Admiralty, and in this country by the Admiralty Research Laboratory. This work resolved many of the optical and mechanical problems associated with underwater equipment, and it may be wondered why the extension to television has not occurred before. The reasons are not far to seek. Television equipment has been very bulky, costly, unreliable, and most important of all, insensitive. The advances during the war in the U.S.A. and the impact of radar techniques on electronic circuitry in general have removed many of these difficulties. The first really successful underwater system was used by the Cornell Aeronautical Laboratory of the U.S.A. in 1947, but was confined to five short tests and not put to operational use.

This article attempts to give an overall picture of the present state of the art in this country, with some comment on possible applications in the light of experience gained by the Royal Naval Scientific Service up to the present.

In May 1951 it became apparent that the search for the wreck of H.M.S. *Affray* was resolving itself into the identification of the many unknown wrecks in the search area located by acoustic means. Fortunately at this critical time the Admiralty Research Laboratory was in a unique position. Not only was the accumulated experience of underwater photography available but also some considerable knowledge of the performance of modern television cameras had been gained from laboratory investigations. A modern image orthicon chain of the normal commercial type was about to be delivered from Marconi's Wireless Telegraph Co. An improvised underwater casing (Fig. 3) was rapidly designed and built round this camera by scientists of the Royal Naval Scientific Service and within three weeks it was installed in H.M.S. *Reclaim*, then engaged in the arduous task of examining and identifying a large number of Asdic contacts.

The success of this camera is now well known. The two historic photographs taken from the screen on June 14 with a hand-held camera which happened to be available are shown in Figs. 1 and 2. These are merely 'snap-shots' of the screen and inevitably are of very poor quality compared with the original image. During the five months occupied by the search for and survey of *Affray* the television camera was operated for over 300 hours under water by R.N.S.S. personnel, and demonstrated the practicability and utility of underwater television even in this elementary form.

Since the *Affray* investigations, extensive trials have been undertaken by the R.N.S.S. with two further cameras with a view to evaluating the scope and limits of underwater television. Up to the date of writing these are the only field trials which have been carried out in this country.

Visibility under water is a variable quantity. By picking the location very clear water can be found, but coastal waters are often of mediocre quality and much water, in the vicinity of estuaries etc., is to all intents and purposes opaque and useless for television or photography. The *Affray* site, about ten miles north-west of the Casquets, and far removed from contaminating sources, had, on the whole, comparatively clear water, and visibilities of up to 40 ft. were occasionally obtained. Even after prolonged bad weather, work was never prevented by turbid water, a range of 15 ft. being the minimum. In other parts of the world, for instance in extensive areas of the Mediterranean, clear water is more readily found and, with photography, ranges of 80–90 ft. have been obtained.

Artificial lighting is generally required to provide

sufficient light intensity for television in British coastal waters except in shallow water under good conditions. Its use, however, does not improve visibility and in some circumstances may actually worsen it, owing to the difficulty of placing lights in an advantageous position. The situation may be likened to that of driving at night in a fog. About the best that can be done is to keep the lights behind the lens, as far away from it as practicable, and to shield the lens from all light except that actually required for illuminating the field of view.

At any rate, in British waters trials have shown that there is no advantage in any particular spectral distribution of the light source, because the scattering particles in the water are large and non-selective in their effects. In clearer waters, particularly where there is an abundance of Kalle's 'yellow-substance'—an unfilterable yellow dye which is believed to be of organic origin and which is generally present in coastal waters—there may be some advantage in a yellow light source, e.g. sodium discharge, but only from the point of view of light penetration, and not from reduced scattering. In the clearest water, where such scattering as is present must be mainly molecular in origin, the longer wavelength sources may have an advantage but this can only be slight. The preceding remarks do not necessarily apply to direct vision or photography where other factors must be taken into account. Most photographic emulsions, for example, produce a higher contrast picture when exposed to red light; this is not, of course, relevant to the television problem. For convenience, therefore, tungsten lighting has generally been used up to the present, a 1½ kilowatt diver's lamp suitably shielded being employed with the *Affray* camera.

The main optical problem is to provide a wide field of view into water. This is made necessary by the close approach of the camera to its subject. Simply to place a lens behind a plane glass window restricts the field considerably, owing to the refraction effects where the glass meets the water. Spherical windows have been used on trials—an idea which has been taken up commercially—but these are not very good in practice. It has been possible, however, to achieve a field of 70° angle through a plane window by various simple devices. Thus a great advance has been achieved as compared with the original camera which has a field of 25° only.

With regard to picture definition, existing television equipment built to broadcast standards has a better performance over a closed circuit (i.e. not involving radio transmission) than is likely to be required for most underwater use.

There are three models of television cameras which can be applied to underwater use at present available in this country. Two of these employ image orthicons—a very sensitive camera tube of American origin but produced in this country by the English Electric Valve Co. The third uses a C.P.S. Emitron tube made by Electric and Musical Industries Ltd. This latter type is being used in a camera developed by E.M.I. Ltd., for the Scottish Marine Biological Association.*

The choice of camera must be considered in relation to the specific purpose for which it is being built. Although some direct comparison of cameras has been done by the R.N.S.S., insufficient data exist for any dogmatic assertions to be made.

All these cameras have been intended for broadcast use and, as such, are far more elaborate than is necessary for closed-circuit television. The increasing demand for simplified equipment for a wide range of non-broadcast applications will, it is hoped, result in cheaper, more compact and more easily maintained gear. Such equipment is already available in the United States.

The problem of the complex, multicore, underwater cable to link the camera to the surface was satisfactorily solved by the British Insulated Callendars Cables Co. at very short notice.

The provision of a watertight casing for use with cameras is not a formidable undertaking. All that is needed is sound engineering, common sense and, most important of all, knowledge of the conditions under which the equipment will be used.

Applications

At the present stage, the number of possible applications for underwater television which spring to mind is apt to be bounded only by imagination. However, some of the more obvious applications of general interest are:

(*a*) Sea-bed survey.
(*b*) Salvage and ship's hull inspection.
(*c*) Dock and harbour work survey.
(*d*) Marine biological and oceanographical research.
(*e*) Fisheries (Fig. 4).

Sea-bed survey for determining the nature of the sea-bed surface *in situ*, of considerable interest to oceanographers, forms perhaps the simplest application. Some incidents from trials may illustrate the possibilities, if it is borne in mind that the existing simple equipment was not specifically adapted to this task, nor was this application directly under investigation.

On the occasion of a demonstration, a diver was sent down to operate underneath the camera (at about 120 ft. depth). The nature of the bottom was determined from the screen as being of coarse gravel ranging from ½ in. to 3 in. with a slight admixture of coarse sand. The diver was instructed to gather a sample, which he was observed to do. Examination of this completely confirmed the detailed information obtained from the screen. This result was obtained with the camera some 10 to 15 ft. above the bottom, a closer approach being impossible due to lack of remote optical focusing.

One of the 'contacts' investigated in the search for the *Affray* was a formation on the bottom revealed by echo-sounder to be semicircular in plan, some ¼ mile across and rising to a height of 50 to 60 ft. from the sea-bed, rather like a circular disc half buried at an angle in the bottom. As a possibility existed of the *Affray* being close to the steep edge of this formation where it might not be distinguishable acoustically, it was investigated by camera, the depth being rather more than 200 ft. A search of about an hour covered most of the surface and showed that it was

* See article "Underwater Television and Marine Biology", by Dr. H. Barnes of the Scottish Marine Biological Association; *Nature*, 1952, Vol. 169, p. 477.

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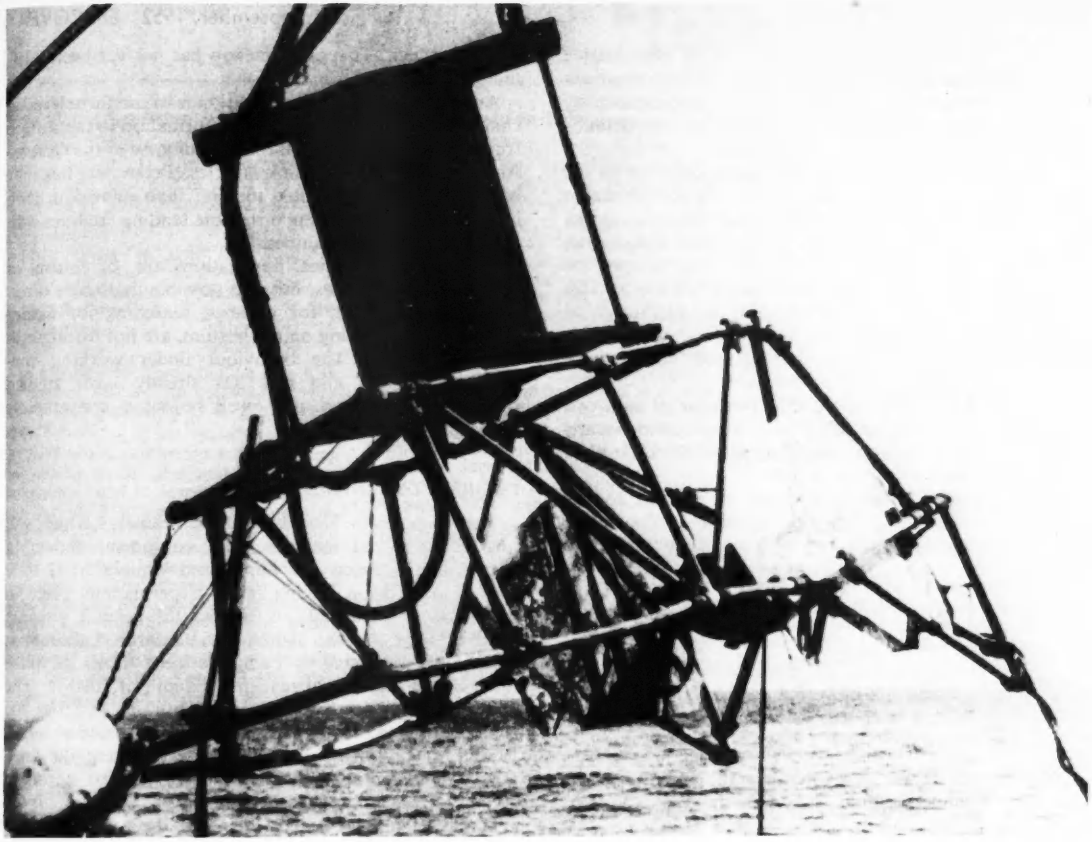
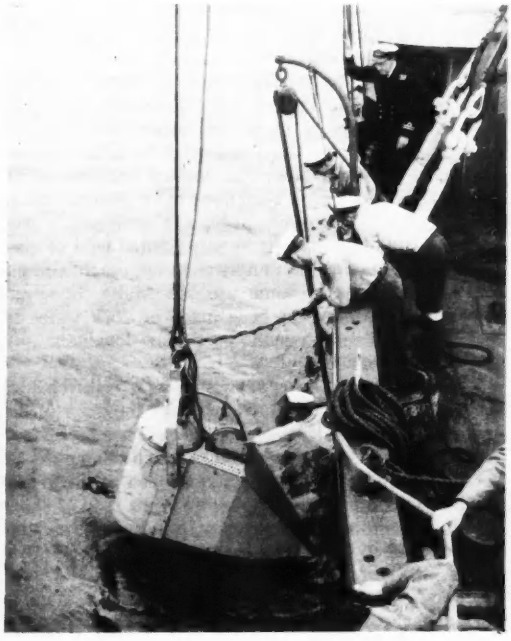


FIG. 3 (*above*).—The television camera used in the *Affray* search with its improvised underwater casing.

FIG. 4 (*below*).—Dogfish as viewed by the same television camera. Marine biology is one field of research in which underwater television is likely to be useful.

FIG. 5 (*right*).—The range of the Pye underwater television camera is about 1000 feet. Here it is being lowered from H.M.S. *Reclaim* off Falmouth to obtain clear views of a war-time wreck 240 feet below the surface. The camera has a built-in lamp to illuminate the underwater scene. By remote control from the ship's bridge (where the television screen is situated) any one of its four lenses can be brought into position to give close-up or wide-angle shots.



a smooth, featureless sand hillock, devoid of even marine life with the exception of a solitary crab. These formations occur not infrequently in the Channel. Investigation by bottom sampler reveals their nature but not the detailed structure or configuration of the surface.

Another example of a sand formation occurred in the vicinity of Smith's Knoll, where a series of regular waves about 15 ft. high and 700 to 800 ft. long was observed by echo-sounder at a depth of about 16 fathoms. The camera showed them to be fine sand, the surface also bearing the small ripple formation often found on the sea-shore. This fact could not have been ascertained by any method other than diving. As the ship was not even moored for this investigation, the speed and simplicity of the television method is obvious.

The presence, distribution and appearance of rock and weed formations are also most easily investigated visually since any normal bottom-sampling method is confined to scattered points.

The application to salvage operations was, of course, vividly illustrated by the *Affray* operations. The major advantages in wreck survey may be summarised as follows:

(*a*) The camera is capable of working deeper than a diver and for longer periods even than an observation chamber.
(*b*) There is no risk to life.
(*c*) The picture is presented directly to experts on the surface and not by verbal descriptions.
(*d*) Manœuvring is enormously simplified by the direct observation.

The ease of manœuvring renders the use of salvage grabs etc. relatively simple. It is a fascinating experience to place a diver's shot line, salvage grab or other device, solely with the aid of the camera, accurately to within a few inches. The sense of intimacy is so great that it is difficult to believe that the object in view is some hundreds of feet below the sea surface.

We may consider the inspection of ships' hulls below water and dock and harbour work survey together because they will normally be in similar conditions. The transparency of the water in most British harbours needs no comment. It would seem that limited use only is practicable. Some work has been done in an undisturbed non-tidal basin where sedimentation has produced a usable transparency. If, of course, a very limited field of view is required and a correspondingly close approach is feasible, television may be of some use. In Malta, however, a photographic survey has been made of dock walls; it is, therefore, evident that in particular localities, visual methods are feasible.

The use of underwater television as a research tool is fascinating to the scientist. Apart from the work of Beebe and a few other similar exploits, little use has been made of visual methods in oceanographic research. Some work has been done in photographing the sea-bed at great depths and also in continuously photographing a strip of sea-bed, but such shooting is of necessity 'blind' and the subject-matter included is purely a matter of luck.

The study of marine life in its natural habitat is now facilitated. There are also problems such as the 'false bottom' echo obtained in many parts of the world on echo-sounders. This phenomenon has not yet been satisfactorily explained.

Another more general application is to use the television chain as a visual link to transmit information to the surface from instruments placed in the field of view of the camera. Although the television link is in itself complex, this may well prove a more flexible method than providing each instrument with recording or remote reading facilities with their attendant uncertainties.

The marine biological applications are, of course, of interest to the fisheries, but it is possible that more direct uses may be found, for instance, searching for flatfish which, normally living on the bottom, are not distinguishable acoustically. The behaviour under working conditions of trawls and nets has already been studied photographically and may well be more conveniently investigated by television.

Future Possibilities

The Navy is to have two further cameras which will provide improved facilities. The equipment shown in Fig. 5 has replaced the improvised camera in H.M.S. *Reclaim*, television having taken a permanent place in deep diving operations. A camera for general research is also to go to the Admiralty Research Laboratory, where a new casing is being devised. Both of these units will be capable of reaching a depth of 1000 ft. The cameras, made by Pye Ltd., have built-in facilities for changing lenses, focus and aperture whilst under water. With a maximum field of 70°, these represent the most advanced design available at present. The next step is to simplify the camera chain and reduce the size of the camera, the present casings being of the order of 20 in. diameter and 30 in. long. Although small television cameras of a different type are available, their lack of sensitivity at present precludes their use under water. The most promising line at the moment is to retain the present camera pick-up tube but to simplify the electronics and to shape the camera to fit a smaller casing. Still greater depths then become a more practical proposition. The auxiliary problem of simple, satisfactory light sources for general underwater use is also being investigated.

The most promising commercial application would appear to be in salvage operations; the development of remotely operated 'tool' for the camera is not impossible. This opens up the salvage of cargoes etc. from great depths with much greater facility than at present.

In the more remote future, stereoscopic television would greatly aid the interpretation of underwater scenes, particularly wreck examination. The addition of colour would also be of great assistance, particularly when artificial light is used. Underwater colour cine-photography has shown that, using natural illumination, the results are so uniformly tinted (green or blue) that little more information is gathered than with a monochrome picture. With artificial illumination, however, the real colours of the objects are made apparent. Present colour television methods are, however, not sufficiently sensitive except possibly for very specialised applications.

(All pictures in this article are official Admiralty photographs. Crown Copyright reserved.)

Far and Near

Night Sky in September

The Moon.—Full moon occurs on September 4d 03h 19m, U.T., and new moon on September 19d 07h 22m. The following conjunctions with the moon take place:

September				
9d 03h	Jupiter in conjunction with the moon	Jupiter	7°	S.
21d 02h	Saturn ,,	Saturn	7°	N.
21d 14h	Venus ,,	Venus	6°	N.
25d 18h	Mars ,,	Mars	3°	N.

In addition to these conjunctions with the moon, Venus is in conjunction with Saturn on September 15d 23h, Venus being 1·6° S.

The Planets.—Mercury is a morning star, rising at 3h 35m and 4h 50m on September 1 and 15, respectively, and is in superior conjunction on September 24. As it rises about 50 minutes before the sun at the middle of the month it becomes more difficult to observe after this. On September 6, the planet makes a very close approach to Regulus and in fact is in conjunction with this star at 20h. Venus is an evening star, its times of setting at the beginning, middle and end of the month being 19h 20m, 18h 55m and 18h 25m, respectively. It can be seen in the western sky for more than half an hour after sunset, its stellar magnitude being −3·3. A small telescope will show that more than 90% of its disk appears illuminated. Mars, an evening star, sets at 21h 10m, 20h 45m and 20h 25m on September 1, 15 and 30, respectively, stellar magnitude 0·4 to 0·6. At the beginning of the month the planet is a little south of β Scorpii and about a week later it is north of the bright star α Scorpii (Antares)—a star of magnitude 1 whose ruddy appearance makes it somewhat like Mars, but the planet is a little brighter than Antares. Jupiter is visible throughout the night; its times of rising are 21h 05m, 20h 10m and 19h 10m, at the beginning, middle and end of the month, respectively, stellar magnitude −2·2, and it is easily recognised in the constellation of Taurus. Saturn, an evening star, sets less than an hour after the sun during most of the month and only 25 minutes after sunset at the end of September when it will not be an easy object to observe. Throughout the month it is a little north of θ Virginis and its stellar magnitude is about 1.

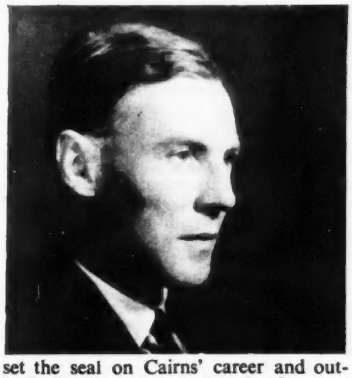
The star Antares, already referred to, is a double star, its companion being about 4 seconds of arc from it. This companion is much smaller than Antares which has a diameter of over 400 million miles, and is, of course, invisible to the naked eye as its magnitude is only 7·5 and, in addition, it is lost in the glare of the brighter star. A small telescope will show that its colour is greenish, which indicates that the companion has a composition very different from that of Antares itself. Colours and spectra of the stars enable astronomers to tell a considerable amount about their temperature and physical condition.

Sir Hugh Cairns: Brain Surgeon (1896–1952)

Sir Hugh William Bell Cairns, K.B.E., D.M., F.R.C.S., Nuffield Professor of Surgery in the University of Oxford, who died on Friday, July 18, is generally recognised as the greatest brain surgeon since Cushing. He was just 56 years old at the time of his death, having been born in South Australia on June 26, 1896.

He qualified as a doctor while serving as a private in the Australian Army Medical Corps in the 1914–18 war. Afterwards he gained a Rhodes scholarship to Balliol College, Oxford, and he proceeded to take a series of House appointments at the Radcliffe Infirmary, before accepting the Hunterian Professorship of the Royal College of Surgeons in 1925.

But it was his visit to America during the years 1926 and 1927 which really



set the seal on Cairns' career and outlook, for it was then that he first met Harvey Cushing, the great American brain surgeon. Cushing was then Professor of Surgery at the Harvard Medical School, and at fifty-seven, was at the height of his career. It was he who developed the method of operating on the brain with local anaesthesia, thus greatly extending the period of time during which the surgeon could work. And in 1912 he had achieved international renown for his work on the pituitary gland.

Cushing had been interested in the possibilities of effective surgery of the brain since his early days at the Johns Hopkins Hospital, although it was not until he went to Harvard and became surgeon-in-chief of the Peter Best Brigham Hospital in 1912 that he was fully able to develop his studies. Up to that time, brain surgery had been almost entirely limited to the attempt to relieve pressure. Pressure in the brain is caused by the pressing in of its bony case following accident, or by the growth of tumours on or near the brain. Since both the grey and white matter of the brain itself is absolutely incompressible, the result of a tumour or pressed-in bone is the squeezing out from the brain of the cerebro-spinal fluid and blood circulating within it. Violent headaches, vomiting and congestion of the optic nerves, leading to blindness, are the common symptoms. Decompression is simply the cutting of an opening in the skull in order to relieve this pressure by allowing the brain to bulge. It was Cushing who, stressing that the bulging brain needs protection, developed the technique of cutting this opening beneath the temporal muscle. Even more important was his mapping of the relatively silent areas of the brain, for damage to these areas meant less damage to the functions of the patient. This was an important consideration when the area released during decompression often suffered from haemorrhage and subsequent impairment of function.

Although on his return to England Cairns first took a general appointment as Assistant Honorary Surgeon at the London Hospital, his interests from this time were concentrated on surgery of the brain, and he later became neuro-surgeon to the London Hospital. He was the first British surgeon to remove a pineal tumour from the brain, and in 1932, when thirty-six, he used for the first time an electrical knife in operating on a tumour of the brain. The development of this knife, which by its heat coagulates the blood in the tissue surrounding the immediate operating area, has in itself helped to revolutionise brain surgery. For one of the greatest dangers is haemorrhage, leading to loss of function.

Although a great specialist, Cairns never lost his belief in the wholeness of the individual. He was particularly interested in the link between personality and disease which he thought profoundly important. Cairns never set up his plate in fashionable consulting rooms, but until he went to Oxford in 1937 as the first Nuffield Professor of Surgery, he saw all his patients in his rooms at the London Hospital. To his patients he was a human and kindly figure, much nearer to them and more interested in their personalities than is usual in the hospital surgeon.

At the Radcliffe Infirmary he worked with success on many special problems. He studied new methods of treating tubercular meningitis, and in March of this year published in *The Lancet* a report on experiments with a new technique for reducing the amount of damage to the personality caused by the standard frontal leucotomy operation. In sixteen psychotic cases, who would normally have been treated by the surgical cutting of the tracts of the frontal lobes of the brain, a new operation was undertaken involving a different area of the brain—the anterior half of that part of the brain known as the *cingular gyrus*. The advantage of this operation is the precisely defined anatomical area affected, and "the slight amount of unwanted personality change of the type sometimes seen after leucotomy", according to the article in *The Lancet* (1952, vol. 162, pp. 475–81), by Cairns and two fellow-workers.

During the war Cairns worked out the clinical use of penicillin with Sir Howard

Florey, and was largely responsible for devising the standard dispatch riders' helmet, which saved many lives. He was in charge of the large Army hospital for brain injuries quartered in St. Hugh's College, Oxford.

Cairns' early death is a great loss that will be badly felt not only in the field of brain surgery, but also in the wider sphere of medical tradition and thought. In both, his passing can be ill afforded.

John Innes Compost

A NUMBER of readers have written asking where they can find details about the preparation of John Innes Compost, and, in particular, details about methods of sterilising it, their inquiries being prompted by the experience of using commercial composts that proved to have been inadequately sterilised. The most comprehensive account of this subject can be found in the book *Seed and Potting Composts*. (London, Allen & Unwin, 8*s*. 6*d*.)

* * *

For a long time John Innes Horticultural Institution has been experimenting with the use of artificial lighting to encourage plant growth; before the war, for example, neon lighting was being tried for this purpose. The latest John Innes Leaflet (No. 11), which is entitled *Artificial Illumination of Seedlings*, states that fluorescent, neon and high-pressure mercury-vapour lamps are all good light sources for the improvement of plant growth, even though they emit of different colours. For seedling illumination the leaflet recommends the 400-watt mercury-vapour lamp, type MA/H. Use of rows of these lamps 4–4½ feet apart brings the average light intensity on seedlings 3–3½ feet below the lamps to about 430 foot-candles, and this improvement over natural illumination brings about a substantial increase in the yield of tomatoes (particularly with early crops) and of cucumbers. This leaflet is published at 9*d*. by Oliver and Boyd Ltd., Tweeddale Court, Edinburgh 1.

Aircraft Designers use Heavy Metal to Save Weight

ANYONE who knows anything of the temperament of aircraft designers would be more than surprised to hear that one of them was searching for the heaviest metal he could find. Some designers have even gone to the length of having a heavy metal specially manufactured. The explanation of this paradox is that for certain special jobs the designer uses the heaviest (or scientifically speaking, the highest-density) metal he can find because he knows that by doing so he actually saves on weight.

The job the metal has to do is to balance the wing and tail surfaces (elevators, ailerons and rudders) which are moved to control the aircraft. If these surfaces are not properly balanced they might begin to flutter in flight.

The space in which the balances can be fitted is restricted. Often they go inside the 'nose' of the control surface, and so the smaller they are, the better.

Besides saving space, heavy metal also saves weight, for this reason: if a metal balance of lighter weight were used, it would have to be larger and so its centre of action would be shifted nearer to the hinge, and thus its balancing effect would be less than required. To make this good, still more metal would have to be added and therefore more weight. This might also mean having to strengthen the structure of the wing and tail to take the extra weight—and so again, more weight.

A special heavy alloy is in fact manufactured for this job by the General Electric Co. It is 90% tungsten.

It is made by mixing the tungsten with nickel, copper and wax to bind it together, and pressing the mixture under 5–10 tons a square inch. When it comes out of the press it has something of the consistency of cigar ash, i.e. it just holds together.

It is then heated in a hydrogen atmosphere to 1000°C., which removes the wax and hardens the compound—without changing its dimensions. Next, it is sintered in a furnace for fifteen minutes, during which time it shrinks by about 20%, increases its density and becomes solid.

Lead is only 60% as dense as heavy alloy which weighs twice as much as steel, but is just as strong.

Royal Charter Granted to London's School of Pharmacy

A ROYAL Charter of Incorporation has been granted to the School of Pharmacy of London University, an event which marks over a century of progress in pharmaceutical education in this country.

The School of Pharmacy was formed by the Pharmaceutical Society of Great Britain in 1842 with the object of establishing a uniform system of education in pharmacy. One of its first tasks was the setting up of suitable laboratories, and the school obtained an early distinction when it opened the first practical chemistry laboratory in Britain in which the subject was taught publicly. In 1888 a research laboratory was established, and, as the field of pharmacy widened, other laboratories were equipped to pioneer developments in pharmaceutical chemistry, bacteriology and pharmacology. By this time the school had acquired an international reputation. Other achievements to the credit of the school were the pioneering of the biological standardisation of drugs, and its work in connexion

A NEW METHOD OF BOAT-BUILDING

A new technique for building boats has been patented by a Bideford firm. It is called "Two-way Tension". The skin material used is a magnesium/aluminium alloy. This is laid flat (see photo above) *and drawn up into shape by tackles attached to a winch. The skin thus tensed becomes an integral part of the ship's structure, and not merely a watertight covering attached to frames. The photo shows the forward part of the hull being drawn into shape. There is still a gap at the prow, which will be closed when the process is completed; the joint will then be riveted.* (Left).—*The 60-ft. motor yacht "Tonquin" built by this method.*

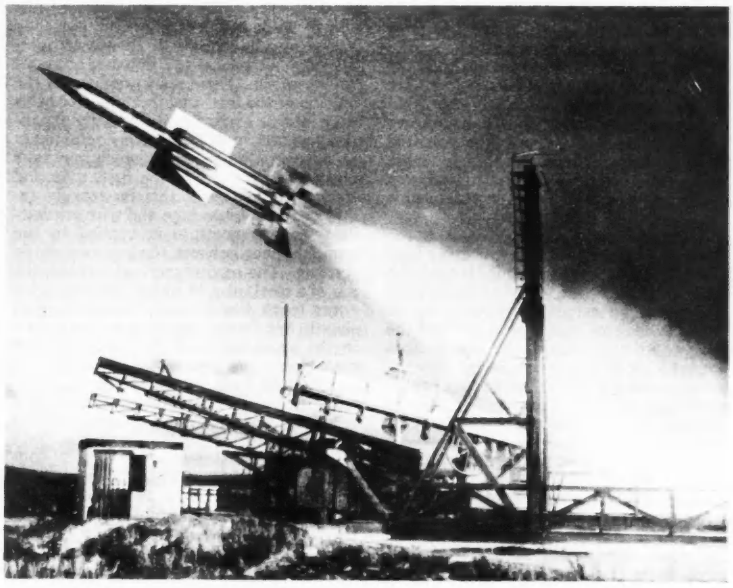
with the British Pharmacopœia. The compilation of the Pharmacopœia itself owes much to the school. In the early days Professors Redwood, Attfield and Greenish were its editors, and when the Pharmacopœia Commission was formed, Professors Berry and Linnell were appointed to it.

In 1926 the institution became a constituent school of London University, which established a B.Pharm. degree. At the same time the university conferred professorial titles on the staff.

Since 1948 the school has been an independent institution, governed by a council which is widely representative of pharmacy and consists of the school's Dean and teachers, nominees of the University of London and the Pharmaceutical Society, together with members co-opted from industry and research; medicine is represented by Sir Archibald Gray, Sir Henry Dale and Dr. Charles Harris, while its chairman is Sir Harry Jephcott.

During the Second World War the school was evacuated to Cardiff. A second move is planned to take place in the near future, when it will move into an imposing new block in Brunswick Square.

Dean of the school is Professor H. Berry, B.Sc., F.R.I.C., who is Professor of Pharmaceutics in London University, who came from the Pharmacy Department of Birmingham's College of Technology.



Britain's guided rockets can travel at well over 2000 m.p.h., are capable of exceeding the ceiling for bombers for years to come, and are able to 'chase' and intercept fighter planes regardless of evasive action. These details about British guided missile development were given recently by the Minister of Supply when he visited Aberporth range (where this photo was taken).

Death of Professor Ehrenhaft

In June 1951, DISCOVERY published an article which dealt with the strange phenomena discovered by the Viennese physicist Felix Ehrenhaft and which contained the following passage:

"Professor Ehrenhaft's position in the academic world is no less odd than the phenomena which he describes. Now a man of seventy-one, he has throughout his life opposed his fellow-physicists. . . . The prolonged and futile controversy about the sub-electrons has made the physicists angry and suspicious against him, and Ehrenhaft's later statements about magnetolysis and other activities of a magnetic current which have not been confirmed by others, have increased their suspicion to such a degree that many firmly refuse to consider his results seriously even when they appear to be correct."

Asked to write an obituary note about Ehrenhaft, I can only add to that passage a few remarks about his personality which was just as likely to provoke controversy and antagonistic feelings as his work was.

A Viennese friend once wrote to me: "Although, as you know, I am a mathematician and know little about physics, I go regularly to his lectures and also his debating classes for advanced students. They are immensely interesting, refreshing and rejuvenating. The students in these classes . . . seem brighter and in higher spirits than elsewhere. The discussion is always lively and full of temperament. It is not at all as in those serious and possibly much better grounded academic lectures where the professor reads from his three-year-old manuscript and the undergraduates doze and accept passively what they are told. In Ehrenhaft's lectures they feel they are standing on a scientific battlefield, in the midst of a heated fight, and they joyfully co-operate in speculating about the problems. Whether Ehrenhaft's theses finally prove to be true or false, his listeners will, at all events, have learnt to think independently, and this is no mean achievement."

When I saw him in Vienna about two years ago, conditioned by strong doses of anti-Ehrenhaft serum which had been administered by his scientific colleagues, both in Germany and in Austria, he overwhelmed me with an almost uninterrupted and uninterruptable torrent of words, in the course of which he called the most celebrated physicists, ignoramuses and imbeciles. After this cataclysm I gratefully accepted the offer of his assistance and retired for a while to his room to rest on his couch and recover my faculties!

It was probably a consequence of his lone-wolf position that he went to great lengths to attract public attention. Thus, he, a very heavily built man of over seventy years, undertook an ascent on to the Sonnblick, a 9000-ft. mountain in the Grossglockner range, and had to be pulled or carried up the last two thousand feet by four alpine guides. At the top he found a confirmation of his expectation, that the photophoresis effects would prove to be more intense at that height and that more particles cling to the light ray than in laboratory conditions.

During the Hitler period, Ehrenhaft lived in the United States. Although the DISCOVERY article of June 1951 was not altogether flattering, Ehrenhaft asserted that it was one of the best ever written about him, adding this remark: "Whenever I have reason to be dissatisfied with something in life, I re-read your article." My Viennese friends tell me that this article was the last joy of his life, for soon afterwards he had a seizure from which he never recovered. He spent the whole autumn and winter in a sad state, dying at last on March 4, 1952.

GABRIELE RABEL.

Flat Cable

EVER since the very earliest days of electric-power transmission the many different types of cables which have been employed have had at least one thing in common: all have been circular in form. Now there is news of the world's first flat cable, invented by Mr. Johs Mollerhoj of the Northern Cable and Wire Works of Copenhagen.

Before describing the construction of this revolutionary advance in cable-making technique and the advantages it brings, one needs to appreciate the difficulties facing the designers of high-tension power cables. Such cables are invariably made with a stranded copper core, insulated with paper tape impregnated with a resinous oil and enclosed in a lead sheath. Where the three cores required for a 3-phase system are covered by a single lead sheath, each core is surrounded by a metallised paper tape in contact with the outside lead sheath. This ensures that electrostatic stresses in the cable papers are radial and not tangential; the paper

tape has stronger resistance to dielectric stress in a direction at right angles to their length than along the surface.

A dielectric of this type must be made as homogeneous as possible; if there are voids or spaces into which the impregnating material has migrated, there is danger of gaseous discharge due to the potential gradient across them, which can cause arcing that eventually leads to charring and ultimate failure. At all costs ionisable spaces must be eliminated.

The main cause of these voids is the expansion of the lead sheath during load cycles. Heavy current passing through the cable generates heat, and this causes the lead sheath to expand beyond its elastic limit. When the load is removed and the cable cools down again, the sheath does not take up its former position; thus the pressure exerted by the lead sheath (which previously held the paper tapes tightly in position) is no longer present, and voids may easily develop.

Two methods have been used to prevent this happening. The first depends on oil pressure inside the cable. A hollow core is used, so arranged that the oil may communicate through the strands and through the paper tapes. The oil is fed into the cable from the reservoirs at each end, either by gravity feed or by means of a pressure type of diaphragm. The oil fills up any voids in the cable.

The second method is to use an inert gas—e.g. nitrogen—at a pressure of about 200 lb. sq. in. This exerts pressure on the outside of the lead sheath, and forces this back into its original position after expansion has occurred. The gas is contained in an outer confining vessel, which may take one of two forms. In the first, a second lead sheath is used; this is strongly reinforced with brass tape and wire armouring; the gas pressure is applied to the annular space between the two concentric sheaths. The second method involves the use of a steel tube, in which the three cable cores (each has its own individual lead sheath) are drawn; gas pressure then exists in the space between the cores and the steel pipe.

Although both methods—the oil-pressure method and the gas-pressure method—are successfully used on large cables operating at the highest voltages, they both have the disadvantage that a considerable amount of terminal equipment is needed.

The new flat cable is oil-filled, but it has its own diaphragm equipment for dealing with the expansion of the oil that occurs during the heating caused by load cycles. It comprises three single-core cables; these are of the conventional paper-insulated type with a metallised paper screen, and they are laid in flat formation and surrounded by a single lead sheath. This sheath is wrapped round with strong bronze tape, and surrounding this is the key item in this new invention—a resilient membrane support, consisting of a springy corrugated bronze tape laid along the length of each of the flat sides, and held in position by stout copper wire. A layer of jute protects the whole against corrosion, and this is covered with the normal steel armouring.

When the loaded cable gets hot, the sheath expands against the spring pressure exerted by the resilient membrane. The oil expands, and its extra volume is accommodated without the need for any form of terminal equipment. On cooling, the oil contracts and the pressure exerted throughout the whole length of the cable by the membrane is sufficient to force the lead sheath back into its normal position.

This kind of cable needs far less copper and lead than the conventional kind, an important economy at the present time.

It is particularly suitable for submarine use, and a 4-mile length of this cable (to carry 132,000 volts) is now being laid between Denmark and Sweden.

J. H. M. SYKES.

The Bookshelf

Men Who Changed the World. By Egon Larsen. (London, Phoenix House, 1952, 224 pp., 12*s.* 6*d.*)

IT takes several different kinds of writers to interpret the achievements of scientists, technologists and inventors to the rest of the community. The task is certainly not one which can be done by the technical men alone. Besides the Haldanes, Andrades and Huxleys, the story of scientific and technological advance requires the talents of a whole chain of writers. Interpretation and popularisation involves a process of digestion, whereby the bare facts, which are recorded in the erudite journals that publish the papers of the research workers, are converted into something that is both intelligible and readable. This process of digestion involves a number of stages, one stage being represented by magazines like *Discovery* and *Scientific American* which have a distinctive part to play, for they add colour and perspective to the rather arid facts published by the research journals, and help to make the significance of new developments apparent to the publicists who reach the millions through national papers and the radio. At that stage we meet the imaginative interpreters; men like John Langdon-Davies, whose writings spark the imaginations of non-technical people who would gain no benefit from ordinary scientific publications.

Egon Larsen comes into this last category. In the preface to this volume he tells how he himself found science difficult when he was a schoolboy, and yet his unscientific brain was ever interested in the achievements of science from the human standpoint—he wanted to know "what goes on in the mind of an inventor or discoverer, and how his inventions and discoveries work". It says much for the efficient work done by the other categories of writers just described, that people like Larsen can find ready at hand and in digestible form the factual information they require as a basis for their new synthesis of facts.

The author has collected a most impressive array of detail, and then extrapolating a little he has dramatised it, taking full advantage of colourful episodes in the inventors' lives, and introducing the kind of dialogue which makes for lively reading. He intended the book for young people, and there is no doubt that he has scored a bull's eye with this work—which, in fact, was only to be expected after the success of his previous volumes called *Inventors' Cavalcade* and *Inventors' Scrapbook*. This new volume reaches the same standard, and can be recommended as an ideal present to give to boys and girls who show any spark of interest in scientific and technical matters.

Annual Review of Nuclear Science, Vol. I, 1952. (Annual Reviews Inc., Stanford, California, U.S.A.)

THIS book consists of between twenty and thirty review articles, each covering part of the field of nuclear science and all written by acknowledged specialists. The book is excellently produced and well documented. All the reviews are necessarily rather condensed and assume that the reader is already to some extent familiar with the subject-matter involved. They are therefore not suitable as an introduction to nuclear science for the lay reader, but will be most valuable in keeping nuclear scientists up to date in part of the field allied to their own.

W. J. A.

Wild Orchids of Britain. By V. S. Summerhayes. (London, Collins' New Naturalist Series, 1951, 366 pp., 21*s.*)

Native Orchids of N. America. By D. S. Correll. (Waltham, Massachusetts, U.S.A., Chronica Botanica; London, Wm. Dawson, 1950, 400 pp., 60*s.*)

THE showy and exotic epiphytic orchi. have long held the centre of the stage, but now the less ornate ground orchids—which at close quarters are seen to be no less lovely and certainly no less interesting botanically—are coming into their own. A vogue is developing for growing ground orchids in gardens; this is now well established in the Antipodes, while in Britain more orchid species which can be easily grown in the ordinary garden are to be seen with each Chelsea Show that passes; three wild Cypripediums (*acaule*, *calceolus* and *pubescens*), for example, are being cultivated on an ever-increasing scale, which is scarcely surprising in view of the

fact that they are quite as easy to grow as gentians.

The horticultural interest in the exotic orchids has favoured the publication of books on orchid cultivation as opposed to straight botanical works, but with the change in interest which followed the realisation that ground orchids are well worth a place in gardens, there is now scope for the 'straight' orchid book which can be useful both to botanists and gardeners.

Nearly twenty years has elapsed since a monograph of native British orchids appeared; that work, by Colonel J. Godfrey, was a monumental study, but because of its high price and limited edition it did not reach a great many readers. There was a need for an up-to-date book on this subject, and this 'New Naturalist' volume by V. S. Summerhayes, the orchid specialist of Kew Gardens, fills the gap most effectively. For the naturalist no better work on native orchids exists, though it does not pretend to exhaust the subject so far as the specialised botanical expert is concerned. The first half deals with the orchid's life-cycle, the various pollination mechanisms, classification, distribution and ecology. The rest of the book is devoted to detailed accounts of British genera and the fifty-odd native species. The final chapters indicate gaps that exist in our knowledge, and contains suggestions about problems which call for further research. There is a key enabling one to identify rapidly and with certainty the different British species, and there are maps summarising conveniently the distribution records of forty-three species. Last, but by no means least, there are many fine colour photographs—mostly taken by Robert Atkinson—of individual orchids flowering in their natural habitats.

Correll's book is a useful addition to botanical literature, for it brings together for the first time information about all the orchids which occur in North America north of Mexico. (Some of these are epiphytic, though the majority are ground orchids.) All the species native to this vast region are illustrated, many for the first time, as well as some of their varieties. These pictures, which are black-and-white, were prepared by Blanche Ames Ames and Gordon Winston Dillon, both of the Botanical Museum of Harvard University, which contains an unsurpassed orchid herbarium amassed by the late Prof. Oakes Ames. This is a systematic work, with a full botanical description of each species, notes on distribution and references to original descriptions. There are also cultural notes wherever records exist about the growing of the particular species.

Leaf Analysis. By H. Lundegardh. Translation of Lundegardh's *Die Blattanalyse*, prepared by R. L. Mitchell. (London, Hilger & Watts Ltd., 1951, 176 pp., 22*s*. 6*d*.)

THE chemical analysis of leaves is very old indeed, and in fact it was information collected by analysts about the elements present in the ash of leaves, etc. which provided a starting-point for the plant physiologists when they set out to find which particular elements were essential to plant growth. Using water-culture and pot-culture techniques in which the elements known to be present in plant tissue were supplied to growing plants in the form of compounds of known composition, they were able to sort out the essential nutrient elements from the others; this line of work culminated in the compilation of a select list of a few major nutrients that was followed later by supplementary lists of the so-called 'trace elements' or micro-nutrients which are constantly being added to as new 'deficiency diseases' which arise in particular plants through the absence of traces of specific elements.

The practical demand for information as to the quantitative requirements (especially for potassium and phosphate) of particular crop plants, arising from the widespread application of artificial fertilisers, gave leaf analysis a fillip some thirty years ago. This line of work developed strongly in the 1940s, and it even gave rise to the attempt to use leaf analysis as a swift aid for mineralogists, the theory being that any element found in foliage must derive from the soil.

One of the most active centres for leaf-analysis work has been the Plat Physiology Institute at Uppsala-Ultuna, Sweden, where research has been focused at the point where plant physiology and soil science meet. This book is a translation of a monograph in which Dr. Lundegardh presents some of the practical results of his investigations in this field.

Spectrographic methods were employed because they were so rapid, and an automatic robot piece of equipment, specially designed to deal with the vast number of solutions investigated, is described in this book. Investigators engaged in plant physiology or applied botany as well as practising spectroscopists should find much to interest them in this work.

The Science of Humanity. By K. G. Collier. (London, Nelson, 339 pp., 12*s*. 6*d*.)

MR. COLLIER sets out to be a modern Humanist, to hold the substance of man's knowledge of himself in the hollow of his hand, to summarise it in one slim volume, and to present it to mankind, to the sixth-former, and especially to the adult student.

Mr. Collier believes that the doubt and uncertainty of our age are largely due to the failure of most of us to obtain a comprehensive picture of the achievements and limitations of the scientific methods. Some are uncertain because they know too little of the achievements of science as a whole; some because the myopia induced by specialisation seems to give rise to a new and powerful class with too little sense of social responsibility, or of mankind and science as a whole. If only we could grasp the whole drift of human knowledge we might at least draw comfort from arriving at a careful appraisal of the situation.

Is the painting of so vast a canvas possible? Mr. Collier is not daunted by the magnitude of the task, nor should the finished work daunt any reader, young or old, technical or non-technical. The author has, in his writing, something of the universality he values so much, and his book is fascinating. Though he rushes, in 300 pages, through the *Science of Human Nature* and the *Science of Human Society*, breathlessly taking in heredity, evolution, instinct, the physical basis of personality, intelligence and its measurement, welfare economics, and the main aspects of sociology, he is in no sense giving a mere catalogue to appal the layman, nor a set of hurried opinions to outrage the specialist. His summaries (for such they must be) are full of interest; while his opinions could not be fully endorsed, they are balanced and tenable.

Does Mr. Collier therefore succeed in giving a rounded confidence or at least a critical respect to our views on science and humanity? Perhaps he does, even to those who are deeply distrustful of science and its works . . . if they could be persuaded to read this book! Does he further the aim of modern humanism? Yes, he does, but there are strong forces working against him. The victory of reason in man's affairs is not yet come; and the cloud of human knowledge, which for the sixteenth-century humanist was no larger than a man's hand (or a man's mind) is now a vast fog for specialists to grope about in under the single unifying influence of the scientific method. Small wonder we are always getting lost, general public and specialists alike. Mr. Collier may not clear the fog for us for long, but we are indebted to him for showing that it can be cleared.

A. I. M.

The Conquest of Space. By Willy Ley and Chesley Bonestell. (London, Sidgwick and Jackson, 160 pp. with 48 paintings, 18*s*.)

SOME years ago I was asked to arrange a series of broadcasts predicting what the world would be like in 2044. Three scientists got down to the job of extrapolating scientific trends for a century ahead, and produced a lot of ideas, including the revival of the Severn barrage scheme, the development of the Hylea region, the use of windmills as power generators, and a lot more which haven't yet been realised. Greatly daring, we ended up with a feature dealing with the projection of unmanned experimental rockets to very high altitudes. As prophets we did quite well, but where we erred hopelessly was in our estimate of the pace of development. Less than ten years have elapsed, and yet it appears that at the present time a rocket could be put into a permanent orbit round the earth as an artificial satellite, and perhaps even projected to the moon. Frankly, a text like Willy Ley's makes me dizzy.

Dr. Ley has acquired the sort of *Sturm und Drang* style of English favoured in some parts of the United States, but I confess to a liking for this kind of thing in small doses. Certainly the facts of

interplanetary rocketry are set out with a dash which lends them additional interest, and the result is eminently readable. One ends with a conviction that passage to the moon, Mars and Venus is not so far outside the range of possibility. Whether the experience would be pleasant it is hard to say.

My enthusiasm for trips to the remaining planets and asteroids is practically nil, and when it comes to a visit to a hypothetical planet circling Mira Ceti, I absolutely refuse to play. This last possibility is suggested by one of Mr. Bonestell's paintings. These illustrations lend the book its greatest interest, and indeed, distinction. The first set deals with long-range terrestrial communication and shows a rocket ship flying over various portions of the earth's surface. In section two we reach the moon, and see some beautiful drawings of lunar surface detail. Section three takes us farther afield—to Mars, Mercury, Venus, and the outer planets, all in colour far more glorious and subtle than the standard to which we have become accustomed. The last section deals with Mars, Jupiter and Saturn. Jupiter I find a trifle disappointing. Mr. Bonestell hedges on the subject of surface detail. He shows nothing beyond a few vague shadows, far less in fact than has been shown in many photographs: infinitely less than can be seen through a large telescope on a really clear night with Jupiter in the zenith. Then all the subtle shades of brown, with hints of green, become visible. The embayments in the most northerly and southerly belts which look for all the world like depression centres about to tear loose from stormy polar regions can easily be seen. Mr. Bonestell has none of this, which is a pity, because he could obviously do it justice.

I am not sure whether this book should be classed as serious astronomy: I don't care very much: I found it entrancing.

D. S. EVANS.

Problems of Life. An Evaluation of Modern Biological Thought. By L. von Bertalanffy. (London, Watts & Co., 1952, 216 pp., 25*s*.)

THIS book requires concentrated reading. This is partly due to the great diversity of the numerous references incorporated in the text; hardly a page passes without reference to three or more scientists (who usually seem to have worked in widely differing specialised fields), a brace of philosophers, and a further couple of other personalities; the result is confusing.

Professor von Bertalanffy wishes to do three things:

(1) To postulate that biological laws are more fundamental than physical laws.

(2) To make the corpus of biology an exact mensurable science on the basis that, like modern physics, all life can in fact be treated as a series of differing but interacting systems.

(3) To isolate metaphysics by the simple expedient of saying that science is not concerned with what really is, but only with what does: with the character of the electron and the animal, not what they really are.

In some ways this is a very laudable project. We do see through a glass darkly, and maybe it is more convenient to confine scientific theory to the reflections of actuality. Scientific method is, after all, specifically designed to study the phenomena (the events) of the Universe and to arrange them in repetitive systems. It describes things in such terms that you can expect that if you do this, that event will happen. This is a natural result of the method of inquiry we term 'scientific experimentation'.

Metaphysics and poetry, though they may abut on the experimental orbit, can have no part in scientific theory. If you regard science purely as a tool in this fashion, it is common logic that biology is more fundamental than physics simply because man knows physics through the background of his own biological existence. It is scarcely novel to regard the living organism within the whole realm of living organisms as a series of interacting dynamic systems each of which obey certain sets of laws. Cells divide according to certain laws and form certain relationships one to another because of their method of division. There are simple relationships between the fertilised egg and all the succeeding offspring, and, indeed, between all the different events involved in all the multifarious processes of living matter. The extension of this approach throughout the whole of biology, and the working out of common laws, has now become a more practical possibility, but the basic concept was accepted and discussed among philosophers centuries ago.

Possibly this highly referenced compendium may help scientists unused to dealing with general thought to understand something of these concepts, but the picture they will obtain will be extremely confused. Good theory and sound thinking is not judged by the weight and number of the learned references incorporated into its exposition.

DEREK WRAGGE MORLEY.

Starting Astronomy. By E. O. Tancock, (London, George Philip & Son Ltd., 132 pp., 10 plates and 19 diagrams, 9*s*.).

THIS book is really a revised and expanded version of the author's *Elements of Descriptive Astronomy* which is now out of print. The book deserves a very warm welcome; it is written by one who has taught astronomy and it is only necessary to read the book to realise how expert a teacher he must be. The whole field of elementary astronomy is very well covered within a surprisingly small compass. The exposition is supplemented by a series of graphical and observational exercises which will leave the serious student with a firm grasp of the fundamentals of astronomy.

The book can be most strongly recommended for use in schools, and to adults seeking instruction as well as astronomical entertainment.

D. S. EVANS.

Dynamic Aspects of Biochemistry. By Ernest Baldwin. (London, Cambridge University Press, 2nd edition, 1952, 543 pp., 30*s*.)

THE first edition of Prof. Baldwin's book appeared in 1947 and provided, for the first time in text-book form, a comprehensive survey of the various reaction systems to be found in living organisms. In this second edition, the author has brought the subject-matter up to date without substantially increasing the size of the book. He has rewritten the outdated passages rather than merely adding the new material on to the old. In Part I of the book (Enzymes), however, a new chapter on biological energetics is included, and the sections on transferring enzymes and oxidising enzymes have been considerably expanded.

The second part of the book (Metabolism) has been more or less completely rewritten. The latest work on the tricarboxylic acid cycle is included, for example the recent findings which substantiate the fact that citric acid arises directly from the condensation of 'active acetate' and oxalacetic acid. The identification of this 'active acetate' with acetyl co-enzyme A instead of acetyl phosphate as was previously thought, has caused the chapter on fat metabolism to be rewritten.

The book, therefore, remains unique in this field, and makes an excellent, up-to-date text-book for those who require a sound introduction to this subject.

Acids and Bases. By R. P. Bell. (London, Methuen; New York, John Wiley, 1951, 90 pp., 6*s*. 6*d*.)

THIS short book, one of the Methuen series of chemical monographs, is an authoritative survey of a fundamentally important topic of physical chemistry. The first part of the book is concerned with the development of the concept of acid and base, and ionic equilibria in water and non-aqueous solutions are discussed in terms of the unifying Bronsted-Lowry definition. Further chapters on "Acid-base Strength and Molecular Structure" and "Acid-base Catalysis" give an up-to-date account of fields with which Mr. Bell has been particularly concerned. The book concludes with a well-balanced appraisement of the recent extended definition of acid and base due to G. N. Lewis.

This book can be strongly recommended, not only for its lucidity and authority, but also for its clear demonstration of the essential interdependence of a wide range of topics.

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